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ASTM BULLETIN

Published by
AMERICAN SOCIETY for
TESTING MATERIALS

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OCTOBER—1941

No. 112

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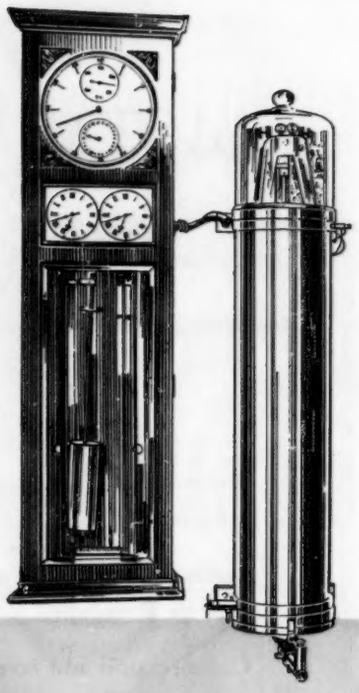

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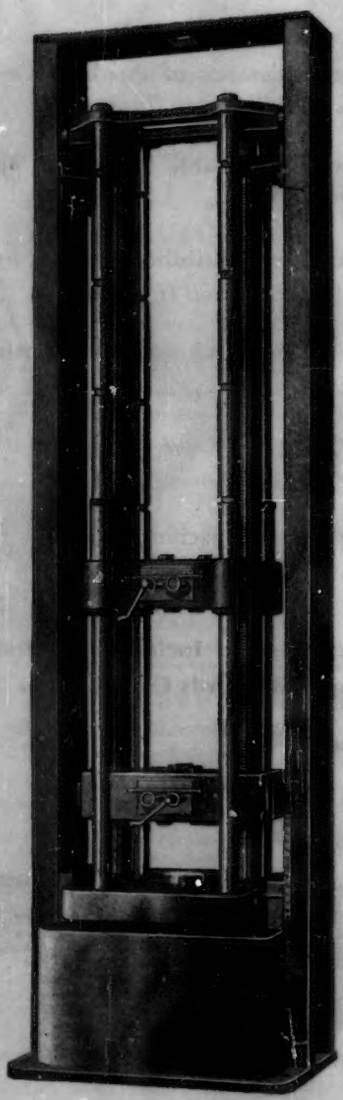

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ASTM BULLETIN

"Promotion of Knowledge of Materials of Engineering and Standardization of Specifications and Methods of Testing"

TELEPHONE—PENnypacker 3545 R. E. Hess, Editor CABLE ADDRESS—TESTING

R. J. Painter, Associate Editor

Number 112 October, 1941

Committee on Standards Approves 37 New Specifications

Numerous Revisions Developed to Keep Standards in Line with Industrial Practice; Procedure for Emergency Alternate Requirements

COMMITTEE E-10 on Standards on August 25 approved 37 new specifications and tests, acted favorably on 15 revisions of tentative specifications, and approved the publication of 11 tentative revisions of standards. This important committee, in the interval between meetings of the Society, acts for it in reviewing recommendations on standards coming from the various technical committees. One of the actions taken involved the first case of an emergency alternate requirement.

Committee E-10 elected J. R. Townsend, Materials Standards Engineer, Bell Telephone Laboratories, Inc., Chairman for a term of one year. The personnel of this committee consists of the following:

J. R. Townsend, *Chairman*, Materials Standards Engineer, Bell Telephone Laboratories, Inc.

R. D. Bonney, Assistant Manager of Manufacturing, Congoleum-Nairn, Inc.

F. H. Jackson, Senior Engineer of Tests, Public Roads Administration, Federal Works Agency.

N. L. Mochel, Manager, Metallurgical Engineering, Westinghouse Electric and Manufacturing Co.

F. E. Richart, Research Professor of Engineering Materials, University of Illinois.

H. S. Vassar (Past-President, A.S.T.M.), Laboratory Engineer, Public Service Electric and Gas Co.

Ex-Officio Secretary: C. L. Warwick, Secretary-Treasurer, American Society for Testing Materials.

Many of the new specifications and tests have been under development for several months—in a few cases much longer because the needed technical data were not available and had to be developed by cooperative test and research programs in the respective groups.

Committee E-10 also reviewed a procedure by which the Society can develop emergency alternate specifications and requirements in standards through expedited committee action. This procedure involves the approval by a duly constituted technical committee, confirmation of the action by the A.S.T.M. standing committee's chairman, and subsequent approval by Committee E-10. Publication and notification of emergency requirements can be in the form of a sticker or sheet which may be affixed to the specification in question. This procedure is, of course, tied in directly with anticipated National Defense needs. A statement from the Regulations Governing Standing Committees concerning emergency alternate actions is published here.

STEEL

Two new specifications developed in Committee A-1 on Steel were approved, covering boiler and superheater tubes. One specification covers carbon-molybdenum material fabricated by electric-resistance welding (A 250 – 41 T), the other covers four grades of austenitic steel fabricated either by electric-resistance or the atomic-hydrogen arc welding process (A 249 – 41 T).

Each of the specifications sets up recognized flattening, flaring, and hardness tests, and also standard hydrostatic tests. The three grades of carbon-molybdenum material are differentiated by chemical and mechanical requirements—tensile strength, for instance, being 53,000, 55,000, and 60,000 psi. with Brinell hardness values of 137 and 143.

Five grades are covered in Specifications A 249, chromium-nickel, chromium-nickel-titanium, chromium-nickel-columbium, and two types of chromium-nickel-molybdenum. Minimum tensile requirement is 75,000 psi., yield point 30,000 psi., with minimum elongation in 2 in. of 35 per cent.

NON-FERROUS METALS AND ALLOYS

Based on intensive work in its Subcommittee VII on Refined Nickel and High-Nickel Alloys, O. B. J. Fraser, chairman, Committee B-2 on Non-Ferrous Metals and Alloys, offered nine new tentative specifications as follows:

Nickel, Nickel-Copper Alloy and Nickel-Chromium-Iron Alloy Seamless Condenser Tubes and Ferrule Stock (B 163 – 41 T)

Nickel-Chromium-Iron Alloy Cold-Drawn Pipe and Tubing (B 167 – 41 T)

Nickel Cold-Drawn Pipe and Tubing (B 161 – 41 T)

Nickel-Chromium-Iron Alloy Rods and Bars (B 166 – 41 T)

Nickel Plate, Sheet and Strip (B 162 – 41 T)

Nickel Rods and Bars (B 160 – 41 T)

Nickel-Chromium-Iron Alloy Plate, Sheet and Strip (B 168 – 41 T)
Nickel-Copper Alloy Rods and Bars (B 164 – 41 T) and
Nickel-Copper Alloy Cold-Drawn Pipe and Tubing (B 165 – 41 T)

All of these materials have been used in pressure vessels, for naval equipment and related categories and in the development of the specifications both the Government and commercial interests have cooperated. A number of users of high nickel alloys were asked specifically to participate in this work.

The specifications follow a somewhat similar outline stating clearly in the scope clause the exact products covered. Chemical limitations are presented, for instance, the first-named specification has three grades of material, nickel, nickel-copper alloy, and nickel-chromium-iron alloy with nickel composition, respectively, of 99, 63 to 70, and 75 per cent; other elements—copper, iron, manganese, chromium, carbon, silicon and sulfur—are covered. Mechanical requirements are clearly set forth in each, covering tensile strength, hardness values, yield strength (0.20 per cent offset), and elongation. In the case of pipe and tubing, expanding and hydrostatic test requirements are given and permissible variations in weight, dimensions, etc., are provided in each of the new standards.

For purposes of classification which must be exact, the committee lists the sizes of material constituting rods, squares, hexagons, and flats.

In the nickel plate, sheet, and strip specifications the classifications are as follows:

Sheet: Material $^1/_4$ in. and under in thickness, and over 18 in. in width.
Strip: Material $^1/_4$ in. and under in thickness, and not over 18 in. in width.
Plate: Hot-rolled material over $^1/_4$ in. in thickness, and over 10 in. in width.

Revisions were approved in two specifications covering, respectively, Nickel-Copper Alloy Plate, Sheet, and Strip (B 127 – 39 T) and for Electrolytic Cathode Copper (B 115 – 38 T). These were modified to bring them in line with current practice and to meet the requirements of certain Government agencies. Changes were made in B 127 physical properties involving upping the tensile strength of quarter-hard sheet and strip from 75,000 to 85,000 to read 78,000 to 85,000. Annealed material (sheet, strip, and plate) must fall in the tensile range of 70,000 to 85,000 psi. New tables of tolerances were included.

Copper and Copper Alloys

One of the Society's most active committees is Committee B-5 on Copper and Copper Alloys. This group has been cooperating very closely with the Army Ordnance and with other divisions of the Government in connection with National Defense work. The most recent developments in the committee are two new tentative specifications approved by Committee E-10 giving standard requirements for phosphor bronze wire (B 159 – 41 T) and rods, bars and shapes (B 139 – 41 T). Three grades of wire are covered, Grade A (tin composition of 3.80 to 5.80 with copper the remainder after certain impurities are deducted) covers material from 0.020 to 0.500 per cent in diameter. Grades C and D with tin, respectively, of 7.00 to 9.00 and 9.00 to 11.00 per cent cover wire from 0.02 to 0.250 in. Tensile strength, varying according to the temper, runs from 43,000 psi.; soft, grade A, to 135,000 psi., hard, grade D; elongation in 2 in. from 9 per cent min.

The new rod, bar, and shape standard provides three grades suitable for structural purposes (bolts, gears, etc.) and two grades are set up for free machining, suitable for screw machine products. Grade classifications are by chemistry and physical values, the machining grades having considerably higher lead composition than the structural grades, one of them also including $3^1/_2$ to $4^1/_2$ per cent zinc, lead and tin being the same, with copper the remainder. Structural grades are marked particularly by differences in the tin composition, this, respectively, being 3.80 to 5.80, 7.00 to 9.00, and 9.00 to 11.00 per cent. Physical requirements vary according to the grade and structural shape, tensile strengths ranging from 50,000 to 95,000 psi. with minimum elongation in 2 in. of 10 to 20 per cent.

After a great deal of discussion the committee was able two years ago to have various interests reach an agreement on specification requirements for Beryllium Copper Alloy Bars, Rods, Sheet, Strip, and Wire (B 120 – 41 T). Because users of the material have requested certain changes in composition, Committee B-5 approved modifications and has included in the Appendix correct heat-treating temperatures. These specifications are being issued as new standards. All material has a beryllium requirement of 1.90 to 2.20 per cent; maximum per cent of additive elements is 0.50; impurities maximum is 0.50; and copper is the remainder. Physical requirements vary according to heat-treated condition and size of the product. Sheet and strip range of tensile strength is from 73,000 to 95,000 psi., but the precipitation hardened material ranges from 150,000 to 180,000 psi.

Clay Pipe; Concrete and Concrete Aggregates

Minor corrections were approved by Committee E-10 in the methods of determining the resistance of clay pipe to acid, these requirements being covered in the Standard Specifications C 13 – 40.

A number of proposed changes in existing standards were developed by Committee C-9 on Concrete and Concrete Aggregates and all of these were approved for publication as tentative. In addition a revision was approved in the test for soundness of aggregates, including provision for larger samples of coarse aggregate in certain cases and for closer control of grading in all cases. It is proposed to modify a number of the concrete standards to establish provisions for grinding the ends of test specimens when making the compression test. Information is also to be incorporated covering certain capping compounds, it being indicated that neat portland or high alumina cement, sulfur compounds, or a mixture of approximately equal portions of portland cement and plaster of Paris are usually acceptable if allowed to harden adequately.

Revisions in the specifications for light weight aggregate for concrete will give an additional grading in the size designation for coarse aggregate, and the maximum unit weight of fine aggregate has been raised from 70 to 75 lb. per cu. ft. to provide for the use of certain material suitable for this purpose.

Glass and Glass Products

Under the direction of the Society's President, G. E. F. Lundell, who is chairman of Subcommittee II on Chemical Analysis, Committee C-14 on Glass and Glass Products

submitted proposed standard referee and routine methods for chemical analysis of soda-lime glass (C 169 – 41 T). After discussion at the 1940 Fall Meeting of the committee as a result of which certain changes were made, they were submitted to five laboratories for trial in the analyses of the National Bureau of Standards Standard Samples Nos. 80 and 128 of soda-lime glass.

This committee has a very active program of work under way and at the Society's annual meeting this year submitted a proposed standard definition of the term "glass" which includes a classification of glasses according to components, that is, whether one, two, or multi-component glasses. The committee also has under development testing procedures for determining chemical durability and for making determinations of the thermal endurance of glass. Quite an extensive series of research investigations have been carried out by the subcommittee concerned with glass construction block and tile, and cooperative tests have involved individual glass block, panels, and mortars used with the blocks.

Building Brick

Because of the widespread use of brick as a building material, there is always keen interest in the quality specifications covering it. The Society's Committee C-15 on Manufactured Masonry Units developed changes in the Tentative Specifications for Building Brick (Made from Clay or Shale) (C 62 – 40 T) which include certain changes in physical requirements and an amplification and clarification of provisions concerning appearance. Perhaps of particular interest was the decision to include an explanatory note or preface which gives information on the source, reliability, and limitations of the specifications. Points discussed in this preface include size, color, and texture, compressive strength, durability and suction when laid. Particular emphasis is devoted to durability but all of these factors affect the appearance and performance of masonry.

"Broken Tensile Specimens"

Second prize-winning photograph, Nonprofessional, in the Fourth A.S.T.M. Photographic Exhibit, by Mason Clogg, Jr., Rustless Iron and Steel Corp.

Road and Paving Materials

In addition to several suggested changes in its existing standards, Committee D-4 on Road and Paving Materials offered two new specifications, one covering sodium chloride (D 632 – 41 T) for which no specifications at present are in existence, another for slow-setting emulsified asphalt (D 631 – 41 T) which type is very widely used throughout the United States. In the former, the material covered is to be used for road purposes. It must have a minimum NaCl content of 98 per cent, except that if the purchaser samples material after delivery, 0.5 per cent variation is permitted. In the form of rock salt, 12 per cent maximum can be retained on a No. 4 sieve, 60 to 95 per cent on a No. 8, and 7 per cent maximum can pass a No. 30 sieve. Evaporated salt can be used. The latter standard supplements existing A.S.T.M. specifications for quick-setting emulsion and for coarse aggregate mixing emulsion. There has been considerable discussion and controversy over the requirements and as originally proposed these included dehydration and modified miscibility tests. The dehydration test was removed and the modified miscibility test has been set up as an optional part of the requirements. Changes proposed in a number of the other Committee D-4 standards include standard size of coarse aggregate, sampling bituminous materials, requirements for crushed slag and crushed stone to bring the requirements in line with other A.S.T.M. specifications or tests and to make the material more complete, and in one or two cases to bring the requirements in line with certain Government proposals.

Another important recommendation approved by the Standards Committee emanating jointly from Committees D-4 and D-8 on Bituminous Waterproofing and Roofing Materials covered volume correction tables for tar and coal-tar pitch which were prepared by the National Bureau of Standards as a convenient method for reducing volumes of road tar and coal tar pitch to the basis of 60 F. when extreme accuracy is not required.

Paper and Paper Products

Six important new tentative methods of test for various properties of paper and related products were completed by A.S.T.M. Committee D-6 on Paper and Paper Products and have now been approved as A.S.T.M. tentative methods. They cover the following:

Folding Endurance of Paper (D 643 – 41 T)
Quantitative Determination of Moisture in Paper (D 644 – 41 T)
Thickness of Paper and Paper Products (D 645 – 41 T)
Basis Weight of Paper (D 646 – 41 T)
Conditioning Paper Board and Fiber Boxes for Testing (D 641 – 41T)
Compression Tests on Corrugated and Solid Fiber Boxes (D 642 – 41T)

The folding test involves the use of either the Schopper or the M.I.T. machine, the latter being adjustable for papers of any thickness, while the Schopper equipment is designed for material not over 0.01 in. in thickness. The committee points out that there is no constant rela-

ACTIONS BY COMMITTEE E-10 ON STANDARDS

NEW TENTATIVE STANDARDS

Ferrous Metals

Specifications for Steel (Committee A-1):
Atomic-Hydrogen-Arc-Welded and Electric-Resistance-Welded Alloy-Steel Boiler and Superheater Tubes (A 249 – 41 T).
Electric-Resistance-Welded Carbon-Molybdenum Alloy-Steel Boiler and Superheater Tubes (A 250 – 41 T).

Non-Ferrous Metals

Specifications for Refined Nickel and High-Nickel Alloys (Committee B-2 on Non-Ferrous Metals and Alloys):
Nickel, Nickel-Copper Alloy and Nickel-Chromium-Iron Alloy Seamless Condenser Tubes and Ferrule Stock (B 163 – 41 T).
Nickel-Chromium-Iron Alloy Cold-Drawn Pipe and Tubing (B 167 – 41 T).
Nickel Cold-Drawn Pipe and Tubing (B 161 – 41 T).
Nickel-Chromium-Iron Alloy Rods and Bars (B 166 – 41 T).
Nickel Plate, Sheet, and Strip (B 162 – 41 T).
Nickel Rods and Bars (B 160 – 41 T).
Nickel-Chromium-Iron Alloy Plate, Sheet and Strip (B 168 – 41 T).
Nickel-Copper Alloy Rods and Bars (B 164 – 41 T).
Nickel-Copper Alloy Cold-Drawn Pipe and Tubing (B 165 – 41 T).

Specifications for Copper and Copper Alloys (Committee B-5):
Phosphor Bronze Wire (B 159 – 41 T).
Phosphor Bronze Rods, Bars, and Shapes (B 139 – 41 T).

Road and Paving Materials

Specifications for (Committee D-4):
Slow-Setting Emulsified Asphalt (for Fine Aggregate Mixes) (D 631 – 41 T).
Sodium Chloride (D 632 – 41 T).
Tentative Volume Correction Table for Tar and Coal-Tar Pitch (D 633 – 41 T). *Committees D-4 and D-8.*

Glass and Glass Products

Methods of (Committee C-14):
Chemical Analysis of Soda-Lime Glass (C 169 – 41 T).

Paper and Paper Products

Methods of (Committee D-6):
Test for Folding Endurance of Paper (D 643 – 41 T).
Test for Moisture in Paper and Paper Products (D 644 – 41 T).
Test for Thickness of Paper and Paper Products (D 645 – 41 T).
Test for Basis Weight of Paper and Paper Products (D 646 – 41 T).
Conditioning Paperboard and Fiber Boxes for Testing (D 641 – 41 T).
Compression Tests on Corrugated and Solid Fiber Boxes (D 642 – 41 T).

Electrical Insulating Materials

Specifications for (Committee D-9):
Molds for Tests Specimens of Molding Materials for Electrical Insulation (D 647 – 41 T).

Methods of (Committee D-9):
Test for Product Uniformity of Phenolic Laminated Sheets (D 634 – 41 T).
Testing Molded Materials Used for Electrical Insulation (D 48 – 41 T).
Test for Distortion Under Heat of Molded Electrical Insulating Materials (D 648 – 41 T).
Test for Compressive Strength of Electrical Insulating Materials (D 649 – 41 T).
Test for Flexural Strength of Electrical Insulating Materials (D 650 – 41 T).
Test for Tensile Strength of Electrical Insulating Materials (D 651 – 41 T).
Test for Impact Resistance of Plastics and Electrical Insulating Materials (D 256 – 41 T). *Committees D-9 and D-20.*

Rubber Products

Methods of (Committee D-11):
Testing Asphalt Composition Battery Containers (D 639 – 41 T).
Sampling and Testing Rubber Latex (D 640 – 41 T).

Plastics

Methods of (Committee D-20):
Test for Flammability of Plastics, Over 0.050 in. in Thickness (D 635 – 41 T).
Test for Surface Irregularities of Flat Transparent Plastic Sheet (D 637 – 41 T).
Test for Diffusion of Light by Plastics (D 636 – 41 T).
Tension Testing of Plastics (D 638 – 41 T).
Test for Impact Resistance of Plastics and Electrical Insulating Materials (D 256 – 41 T). *Committees D-9 and D-20.*

REVISIONS IN EXISTING TENTATIVE STANDARDS

(Incorporated Immediately)

Tentative Specifications for:
Electrolytic Cathode Copper (B 115 – 41 T).
Nickel-Copper Alloy Plate, Sheet, and Strip (B 127 – 41 T).
Beryllium-Copper Alloy Bars, Rods, Sheet, Strip, and Wire (B 120 – 41 T).
Building Brick (Made from Clay or Shale) (C 62 – 41 T).
Crushed Stone for Bituminous Macadam Base and Surface Courses (D 192 – 41 T).
Standard Sizes of Coarse Aggregate for Highway Construction (D 448 – 41 T).
Crushed Slag for Bituminous Macadam Base and Surface Courses (D 487 – 41 T).
A.S.T.M. Thermometers (E 1 – 41 T).

Tentative Methods of:
Test for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate (C 88 – 41 T).
Sampling Bituminous Materials (D 140 – 41 T).
Sampling and Testing Untreated Paper Used in Electrical Insulation (D 202 – 41 T).
Test for Thickness of Solid Electrical Insulation (D 374 – 41 T).
Chemical Analysis of Rubber Products (D 297 – 41 T).
Test for Resistance of Plastics to Chemical Reagents (D 543 – 41 T).
Impact Testing of Metallic Materials (E 23 – 41 T).

TENTATIVE REVISIONS OF STANDARDS

(Not incorporated, but published for comment)

Standard Specifications for:
Clay Sewer Pipe (C 13 – 40).
Lightweight Aggregates for Concrete (C 130 – 39).
A.S.T.M. Thermometers (E 1 – 39).

Standard Methods of:
Making and Storing Compression Test Specimens of Concrete in the Field (C 31 – 39).
Test for Compressive Strength of Concrete (C 39 – 39).
Securing Specimens of Hardened Concrete from the Structure (C 42 – 39).
Test for Compressive Strength of Concrete Using Portions of Beams Broken in Flexure (Modified Cube Method) (C 116 – 39).
Test for Specific Gravity and Absorption of Coarse Aggregate (C 127 – 39).
Test for Specific Gravity and Absorption of Fine Aggregate (C 128 – 39).
Test for Ductility of Bituminous Materials (D 113 – 39).
Chemical Analysis of Calcium Chloride (D 345 – 34).
Testing Shellac Used for Electrical Insulation (D 411 – 40).

tion between the values obtained with the two types of apparatus. The method for quantitative determination of moisture in paper applies to all paper and paper products except those that have materials other than water volatile at 100 to 105 C.

Five methods are set up for determining thickness of paper, classified according to the general type of products. For instance, Method A is for the general run of papers whereas Method D is applicable to electrical insulating materials, and Method E for paper under 0.002 in. in thickness.

The test for basis weight of paper and paper products is applicable to both large and small pieces and includes in the Appendix factors for conversion of basis weight from one commercial size to another.

The committee has had a number of conflicting expressions concerning its work on the standard test for conditioning paper board and fiber boxes for testing but has agreed on essential portions of the new standard. In it a standard condition is defined which consists of a circulating atmosphere maintained at a relative humidity of 50 per cent ± 2 per cent and a temperature of 73 F. ± 2 F., except that the variation in temperature alone shall not be of such magnitude as to cause a variation in relative humidity greater than that stated.

The work on corrugated and solid fiber boxes resulted in the acceptance of the new A.S.T.M. standard for compression tests.

In much of its work, this A.S.T.M. technical committee, which comprises, as do all other A.S.T.M. groups, representation from consumer, general interest, and producer groups, has cooperated closely with the Technical Association of the Pulp and Paper Industry and some of the TAPPI methods have formed the basis of A.S.T.M. standards.

Electrical Insulating Materials

A great many of the problems confronting Committee D-9 on Electrical Insulating Materials have been resolved either by close cooperation with other groups or by a series of round-robin or inter-laboratory tests on the part of the members of this very active committee. By action of Committee E-10 a number of D-9 recommendations were approved including a new test for product uniformity of phenolic laminated sheet which was prepared in cooperation with the Navy Department (D 634 – 41 T). In the scope clause it is indicated that the methods cover the procedures for six tests which serve to check the uniformity of the properties of a particular type or grade of phenolic laminated material produced by a particular manufacturer, and to make evident variations in portions of one particular shipment, or in shipments made from time to time. These methods do not in themselves necessarily indicate the quality of a material, or in what degree it may be suited to a particular application. Tests covered include the following: thread count and ply thickness, acetone extractable matter, water absorption, dielectric strength parallel with laminations after immersion in water, hot Rockwell hardness, and density.

The revision in the methods of sampling and testing untreated paper used in electrical insulation (D 202) provides for the dead weight dial micrometer in addition to the machinists' micrometer, and specifications for the equipment are included. This same situation applies in connection with the change proposed in the test for thickness of solid electrical insulation (D 374).

Perhaps of outstanding interest were the extensive changes involving rearrangement of material in the Standard Methods of Testing Molded Materials Used for Electrical Insulation (D 48 – 39). The committee is removing from this standard the several different separate methods required in the complete cycle of tests, each one being set up as a separate procedure with a specific reference given to the other A.S.T.M. tests applicable. In the case of four of the requirements, however, covering compressive strength, tensile strength, distortion under heat, and flexural strength, separate new methods were drafted since they were not covered in existing procedures.

Revisions proposed in the Methods of Testing Shellac Used for Electrical Insulation (D 411 – 40) include the addition of a test for orpiment and a clarification of the description of the apparatus used for the flow test.

Rubber Products; Emergency Alternate Requirements

While two new test methods approved on the recommendation of Committee D-11 on Rubber Products are of distinct importance covering Sampling and Testing of Rubber Latex (D 640 – 41 T) and Testing Asphalt Composition Battery Containers (D 639 – 41 T) probably of most interest at the E-10 meeting was the emergency alternate modification of the Standard Specifications for Insulated Wire and Cable (D 27 – 41). This is the first emergency revision invoked in A.S.T.M. standards and was occasioned by the

Procedure for Emergency Requirements and Specifications

Emergency Alternate Requirements are issued by the Society in the interest of expediting procurement or conserving strategic materials during the period of National Emergency. They are intended for use where they may be considered by the purchaser of the material as a permissible alternate for the specific application or use desired.

Such emergency alternate requirements shall first have the approval of the appropriate subcommittee of the sponsoring committee or duly appointed subgroup of that subcommittee and shall have the endorsement of the chairman of the main committee. The emergency requirements shall then be submitted to Committee E-10 for approval for publication. If approved they shall be published with the specification either in the form of a sticker or as an accompanying sheet and shall also be published in the next succeeding issue of the ASTM Bulletin. Any emergency requirements approved during the year shall be recorded in the next annual report of the standing committee. All such requirements are subject to annual review and the standing committee shall annually report its recommendations with respect to them.

A.S.T.M. standing committees may also find it appropriate to issue complete emergency alternate A.S.T.M. specifications similar to those issued by the Federal Government. The procedure to be followed by the committee in the development of such alternate specifications shall be the same as that indicated above for the approval of emergency alternate requirements.

difficulty manufacturers of wire and cable are having in procuring the type of sheeting specified. Present requirements and the alternate are as follows:

	Lbs. per sq. yd.	Yd. per lb. 40 in. Width	Thread Count
A.S.T.M. D 27	0.25	3.60	56 × 60
Alternate (a)	0.225	4.00	60 × 52
Alternate (b)	0.210	4.30	56 × 48

There is a shortage of 3.60 sheeting and while there will be still a shortage of material, with alternates some relief would be experienced. At the same time the quality of the cables will not be changed because of the use of alternates, and the production of the finished material can continue under A.S.T.M. specifications.

The Methods of Sampling and Testing Latex cover procedures most urgently needed. Extensive use of the material for adhesives and manufacture of various articles has resulted in the necessity for control tests. The methods are to be employed for sampling and for measuring the variability of normal and concentrated rubber latex. In connection with its recommendations the committee considered the proposed method developed by the Crude Rubber Committee of the American Chemical Society. In presenting its new method for Testing Asphalt Composition Battery Containers (D 639 – 41 T) the committee stated, "No standardization exists at present in the methods used for testing this type of battery container which is very widely used. Manufacturers and consumers both agree that standardization is badly needed. Subcommittee XXIII of Committee D-11 has worked on the present recommendation for more than a year and the committee feels that the proposed methods represent the best current practice."

The revisions to be incorporated in the Chemical Analysis of Rubber Products (D 297 – 40 T) greatly improve the instructions for preparation of samples by making them more specific. They also add an alternate apparatus for making extractions which is smaller and permits more accurate weighing. It is anticipated that this will ultimately replace the large form of extraction apparatus. The revisions also call attention to possible errors from decomposable materials which were not covered heretofore.

Plastics

One of the Society committees that has had extensive research programs under way and which has intensified its standardization program, particularly to help in connection with National Defense problems, has been Committee D-20 on Plastics. Several new standards were approved this year at the Society's annual meeting and new standards just completed were approved by Committee E-10 for the Society covering the following:

Flammability Test for Plastic Materials Thicker than 0.050 in. (D 635 – 41 T)
Test for Surface Irregularities of Flat Transparent Plastic Sheets (D 637 – 41 T)
Test for Diffusion of Light by Plastics (D 636 – 41 T)
Test for Tensile Properties of Plastics (D 638 – 41 T)

The new test for flammability is designed to cover all thicknesses of material, whereas the one previously approved, Method D 568, is applicable to sheet material less than 0.050 in. thick. The new method of testing flat plastic sheets for surface irregularities makes use of the prismatic or optical wedge deflection of a beam of light as it passes through a distortion spot or wave in the body of or on the surface of the material being inspected. The material covered by the test would normally be used to cover openings through which visual and instrumental observations are made.

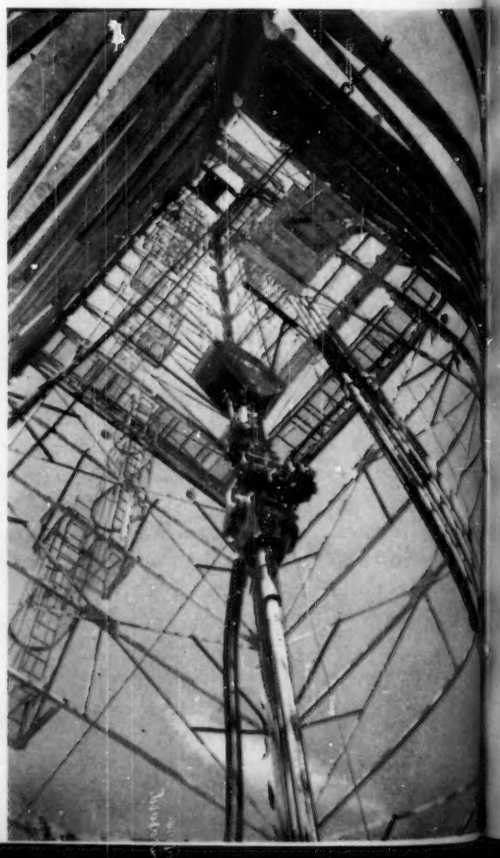
The new method of test for diffusion of light by plastics is designed to differentiate the relative ability to diffuse light among plastics which scatter incident light to an appreciable extent (diffusion). It is not successfully applicable to the measurement of low ranges of scattering (haze), which are associated with slight departures from optical clarity. An instrument and procedure are described for measuring the reflective and transmissive diffusion of a beam of light by a flat plastic sample whose face is essentially normal to the beam axis, with numerical means for rating the scattering or diffusion in terms of a theoretically perfect light scattering surface or medium. The apparatus employed is termed a goniophotometer.

Thermometers

The Society has issued in compact form its requirements for so-called industrial thermometers which are frequently specified in A.S.T.M. test methods. The latest revision of these involves the requirements for aniline point and titer test thermometers; the former is used in connection with tests for aniline point of petroleum. The titer test requirements have been prepared in cooperation with the A.S.T.M.'s Committee D-12 on Soaps and Other Detergents and also the Fat Analysis Committee of the American Oil Chemists' Society and the American Chemical Society.

"Quest for Oil"

By H. M. Frecker, Jr., U. S. Rubber Co. Awarded honorable mention in the Third A.S.T.M. Photographic Exhibit, held in Atlantic City, June, 1940.



Series of National Emergency Steel Specifications to Be Developed; Society Cooperating

Secretary-Treasurer Heads Administrative Committee

A series of National Emergency Steel Specifications which should result in increased production of steel by concentration on a limited number of compositions, sizes, and shapes is the aim of a project recently launched by the Office of Production Management with three national organizations, each of which has been active in this field, carrying out the project, namely, the Society of Automotive Engineers, the American Iron and Steel Institute, and the A.S.T.M. Cooperating closely are the War and Navy Departments.

A.S.T.M. Secretary-Treasurer C. L. Warwick, Consultant in the Office of Production Management, is the administrator of the project and serves as Chairman of the Administrative Committee which consists of representatives from the five bodies named above with advisers from other interested organizations. A list of the members and their alternates, the advisers, and the visitors at the first meeting of the committee on September 12 appears at the end of this article.

Recognition of the importance of this work in the present National Emergency was embodied in the communication from the then Director of Purchases, Donald M. Nelson, inviting the three sponsoring organizations to undertake the work.

A statement of the objective has been approved as follows:

> To establish as promptly as possible a selected list of steel specifications, to be designated as List of National Emergency Steel Specifications, which in effect involves the selection from specifications now promulgated of the minimum number of steel specifications, compositions, and sections necessary to meet the requirements of National Defense, both direct and indirect.

Supplementing this statement, the following statements were also approved.

> It is believed that the productive capacity of the steel industry and of the manufacturing industries using steel for defense requirements can be materially increased within present facilities by concentration of production upon a reduced number of steels, particularly with respect to alloy steels.
>
> It is understood that consideration must necessarily be given to civilian requirements for steel in establishing the List of National Emergency Steel Specifications.
>
> It is the intention of OPM, through its Iron and Steel Section, to use the List of National Emergency Steel Specifications as an aid in administering steel priorities and allocations.

Points stressed during the discussion included the desirability of working from the product to composition; that the ultimate aim in this work is not so much to get more steel as to get more finished parts and machines; and that the design features, which include consideration of drawings and requirements now in effect, must be kept constantly in mind.

The Administrative Committee discussed the extent to which work would involve simplification of sizes and shapes of steel products and recognized that while the work of developing specifications and concentration on a limited number of compositions was of primary significance, reduction in sizes and shapes of products was also essential. The work in this respect will concern basic sizes but consideration will be given to special sizes and shapes for special purposes.

Among the functions of the Administrative Committee in planning and guiding the project will be the designation of technical committees required to do the actual work in developing the list of specifications. A classification of steel products has been made, and committees of technical representatives of both users and producers of steel are being organized. The committees on carbon and alloy steel plates, and on aeronautic steels, will be the first to get under way. These committees will take full advantage of the extensive standardization which has already been accomplished in this field. In all of this work, the committees will keep constantly in mind the degree of scarcity of critical metals and alloying elements and the need for conserving them for the most effective utilization in the defense program.

In all phases of the work and in the development of technical committees' personnel, recognition will be given to the activities of various organizations concerned with this field including such groups as the Mechanical Division and the Engineering Division of the American Association of Railroads, and the American Petroleum Institute and committees functioning in other fields.

Another function of the Administrative Committee will be to review recommendations coming from the various technical committees before they are referred to OPM.

In considering the development of committees and the scope of products, it was decided that special steels as designated from time to time by the War and Navy Departments will be excluded from consideration. Probably on every technical committee, both the War and Navy Departments will be represented and will advise with respect to the limited list of special steels falling in this category.

Considerable progress has already been made in standardization of specifications and simplification of sizes and shapes, mention being made at the meeting of such products as plates, structural shapes, barbed wire, wheels, pipe and tubing, and bars—data on all of which can quickly be made available to the technical committees.

As stated above the committees are to select from existing standards, compositions, and sizes the practicable minimum. This means that advantage will be taken of the extensive work done by the Society's Committee A-1 on Steel and by groups in other recognized standardizing organizations.

In order to tie this work in with the British and Canadian interests, invitations have been extended for them to appoint advisers on the Administrative Committee. The Canadian Engineering Standards Association will designate a leading metallurgist to participate and the British Purchasing Commission will also have one of its technologists follow this work.

From the statements made at the meeting of the Administrative Committee by the various representatives and those present realization of the importance of this project was definitely apparent.

Dr. Lyman J. Briggs of the National Bureau of Standards, who has been much impressed with the importance of this movement, stressed the necessity of reducing to the smallest possible number the types of steels necessary to meet the circumstances and concentrating on the production of those types, drawing our specifications accordingly. The task will not be easy and will require sacrifices, but it is absolutely necessary from the standpoint of production; and by using our best judgments, Dr. Briggs expressed confidence in the ultimate outcome.

ADMINISTRATIVE COMMITTEE ON NATIONAL EMERGENCY STEEL SPECIFICATIONS

MEMBERS:

Representing the American Society for Testing Materials

N. L. Mochel, Manager Metallurgical Engineering, Westinghouse Electric and Manufacturing Co.

Alt., Jerome Strauss, Vice-President, Vanadium Corporation of America.

Representing the Society of Automotive Engineers

F. P. Gilligan, Secretary-Treasurer, Henry Souther Engineering Co.

Alt., J. B. Johnson, Chief, Materials Section, Air Corps, U.S.A.

Representing the American Iron and Steel Institute

E. C. Smith, Chief Metallurgist, Republic Steel Corp.

Alt., C. M. Parker, Secretary, Committee on Manufacturing Problems, American Iron and Steel Institute.

Representing the War Department

Lt. Col. W. R. Slaughter, U.S.A., Chief, Ordnance and Steel Divisions, Production Branch, Office of Under Secretary of War.

Alt., Maj. J. H. Frye, U.S.A., Ordnance, War Department.

Alt., Lt. J. H. Fitch, U.S.A., Standards Divisions, Planning Branch, Office of Under Secretary of War.

Alt., J. B. Johnson, Chief, Materials Section, Air Corps, U.S.A.

*Representing the Navy Department**

Lt. Comdr. E. C. Forsyth, U.S.N., Bureau of Ships, Navy Department.

Alt., Lt. Comdr. J. E. Sullivan, U.S.N.R., Bureau of Aeronautics, Navy Dept. Represented by Lt. A. M. Blamphin, U.S.N.R., Bureau of Aeronautics, Navy Department.

ADVISERS:

H. S. Rawdon, Chief, Division of Metallurgy, National Bureau of Standards.

Alt., W. H. Swanger, Metallurgist, National Bureau of Standards.

N. F. Harriman, Vice-Chairman, Federal Specifications Executive Committee, Procurement Division, Treasury Department.

J. W. McNair, Engineer, American Standards Association.

H. LeRoy Whitney, Executive Consultant, Iron and Steel Section, OPM.

Alt. G. B. Waterhouse, Consultant, Iron and Steel Section, OPM.

C. E. Stryker, Standards Coordination Branch, Aircraft Section, OPM.

C. W. Test, Steel Industrial Specialist, Civilian Supply Division, OPM.

E. J. Hergenroether, Consultant, Conservation and Substitution Section, OPM.

K. D. Williams, Principal Materials Engineer (metallurgical), Bureau of Ships, Navy Department.

Visitors at the Sept. 12 Meeting

Dr. L. J. Briggs, Director, National Bureau of Standards.

Lt. S. D. Daniels, U.S.A. Air Corps, and Army-Navy Aeronautical Board.

T. L. Goudvis, Materials Division, Office of Chief of Air Corps, U.S.A.

J. A. C. Warner, Secretary and General Manager, Society of Automotive Engineers.

R. S. Burnett, Manager, Standards Department, Society of Automotive Engineers.

Donald D. Blanchard, Secretary, S.A.E. Engineering Relations Committee.

R. J. Painter, Assistant to the Secretary, American Society for Testing Materials.

* Other alternates to be appointed.

OPM Advisory Group on Nonmetallic Minerals

THE FOURTH IN THE group of subcommittees which comprises the Advisory Committee on Metals and Minerals appointed by the National Academy of Sciences to cooperate with the Office of Production Management has been organized and the personnel announced; this is the subcommittee on nonmetallic minerals. The personnel of the groups formed previously on ferrous minerals and ferroalloys, metals conservation and substitution, and tin smelting and reclamation were announced in the May, 1941, ASTM BULLETIN.

Clyde E. Williams, Director, Battelle Memorial Institute, is chairman of the main advisory committee. It will be noted from the personnel of the Nonmetallic Minerals Group which follows that a number of the men are A.S.T.M. members and active in various phases of committee work:

NONMETALLIC MINERALS GROUP

R. P. Heuer, *Chairman*, General Refractories Co., 1600 Real Estate Trust Bldg., Philadelphia, Pa.

Paul Tyler, *Secretary*, U. S. Bureau of Mines, Washington, D. C.

L. E. Barringer, General Electric Co., Schenectady, N. Y.

B. C. Burgess, United Feldspar & Minerals Corp., Spruce Pine, N. C.

W. S. Landis, American Cyanamid Co., 30 Rockefeller Plaza, New York, N. Y.

G. R. Mansfield, U. S. Geological Survey, Washington, D. C.

Robert B. Sosman, U. S. Steel Corp., Kearny, N. J.

John D. Sullivan, Battelle Memorial Institute, Columbus, Ohio.

Frank J. Tone, Carborundum Co., Niagara Falls, N. Y.

William M. Weigel, Missouri Pacific Railroad Co., Missouri Pacific Bldg., St. Louis, Mo.

M. M. Leighton, State Geological Survey Division, University of Illinois Campus, Urbana, Ill.

G. A. Bole, Orton Ceramic Foundation, 1445 Summit St., Columbus, Ohio.

R. B. Wittenberg, International Agriculture Corp., 61 Broadway, New York, N. Y.

Oliver C. Ralston, U. S. Bureau of Mines, College Park, Md.

1942 Marburg Lecture Committee

THE COMMITTEE WHICH will select the Edgar Marburg Lecturer for 1942 has been appointed. Under the rules governing the lecture, this group consists of a member of the Executive Committee, a member of Committee E-9 on Research, and a member of Committee E-6 on Papers and Publications. The personnel, representing the respective committees in the order named, is as follows: Past-President W. M. Barr, Chief Chemical and Metallurgical Engineer, Union Pacific Railroad Co., Omaha, Nebr.; Arthur W. Carpenter, Manager of Testing Laboratories, The B. F. Goodrich Co., Akron, Ohio; and H. J. Gilkey, Head, Department of Theoretical and Applied Mechanics, Iowa State College, Ames, Iowa. Doctor Barr is serving as chairman.

Compression and Stress-Decay in Rubber Gaskets[1]

By F. C. Thorn[2]

CONSIDERING THE importance of the gasketed joint in industry, the mechanics applicable to it are in a very obscure state. There is a general recognition of the fact that bolt tensions must be developed of a high enough order to keep the flanges from being blown apart by fluid pressure acting over an area equal to the inside diameter (*A*, Fig. 1) of the gasket. The need is also recognized for enough bolt loading in excess of this to develop a "residual" unit pressure over the gasket area (*B*, Fig. 1) which shall be at least equal to the fluid pressure, as otherwise the fluid will wedge itself into the interface. Formulas for computing the number and size of bolts necessary to secure these combined tensions are hopelessly at variance. In addition to the above there is the fairly well-recognized need for still heavier bolting to produce a residual unit gasket pressure not merely equal to, but at least several times the fluid pressure, to guard against a gradual dying out of stress within the gasket proper. This property of a gasket is known variously as "set" or "plastic flow" but very little is known about its true causes or its extent. This paper is an attempt to explore this property for gaskets cut from a relatively simple rubber compound.

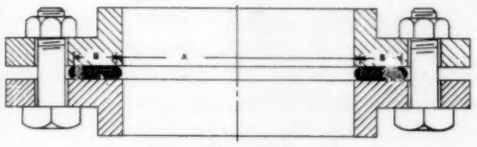


Fig. 1.—A Typical Gasket.

In order to avoid the use of terms containing implications which may not be true, the author proposes to use the term "stress-decay" in describing what happens to a gasket when bolted in a flange and then left alone for a more or less extended period. True gasket stress-decay may be defined as the dying out of pressure exerted by the gasket against the confining flanges under substantially constant volume conditions. In practice, the volume is not precisely constant, since the bolts are stretched, and as the gasket stress diminishes, the bolts relax. Stress-decay, as used herein, may be defined as the dying out of stress directed against the gasket as a consequence of a minute gasket displacement in the presence of stress-generating equipment which has only a limited ability to "follow up." It follows that the stress-decay will be determined by the nature of the tightening arrangements as well as by any property inherent in the gasket or the flange. If long, "stretchy" bolts are employed, we may expect less stress-decay under a given set of conditions than when the same load is applied by short, stumpy bolts.

The apparatus used by the author (Fig. 2) consists essentially of a stack of five steel disks *A*, separated from each other by four gaskets, the entire assembly being sandwiched between sturdy end-plates *B* and compressed by a screw jack and ball joint operating from below, the upper plate being restrained by nuts *C* threaded to three bolts *D* arising from the base of the machine. These bolts are $^3/_8$ in. in diameter, threaded over their entire length, and made of S.A.E. 1040 steel, quenched and drawn at 550 F. Such bolts have been shown to be capable of extensions as high as 0.16 per cent for extended periods without taking any measurable permanent set. Lengths of steel tubing *E* slipped over the bolts form mechanical stops on which the flange assembly rests while the nuts are screwed down finger tight against the upper plate, the bridge *F* is placed over the tapered tips of the bolts, and the dial gage *G*, reading to 0.0001 in., set for zero. The screw jack is then operated until the dial gage indicates any desired degree of stretch. As soon as the screw jack ceases to turn, stress-decay sets in, as indicated by diminishing readings of the dial gage. The dial gages at *H* are attached permanently to the upper end plate, and rest on lugs attached to the lower end plate—they read to 0.001 in. and serve to give a rough measure of the gasket compression which is not essential to the measurement of stress-decay but is included as a matter of interest. The key at *J* serves to prevent the flange assembly from rotating under the action of the screw jack.

An important preliminary step in using this apparatus is to calibrate the bolts. Figure 3 shows a pair of stirrups designed for insertion into an ordinary heavy-duty test machine, one of which rests against the upper plate, while the other bears directly on the ball joint. With the aid of these stirrups the calibration curve shown in Fig. 4 was derived. The initial bolt length of 6 in. corresponds to

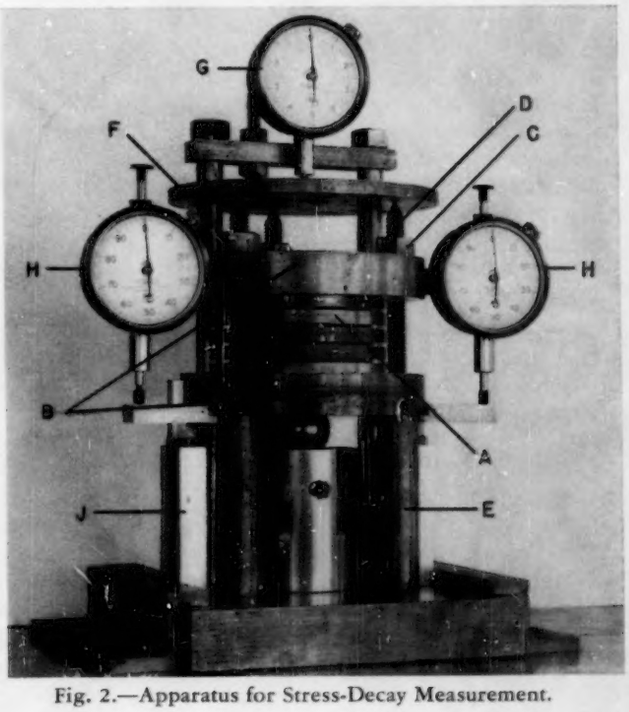


Fig. 2.—Apparatus for Stress-Decay Measurement.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 260 S. Broad St., Philadelphia, Pa.

[1] Presented at meeting of Subcommittee VI on Packings of Committee D-11 on Rubber Products, June 25, 1941, during the annual meeting of the Society at Chicago, Ill.

[2] Chief Chemist, The Garlock Packing Co., Palmyra, N. Y.

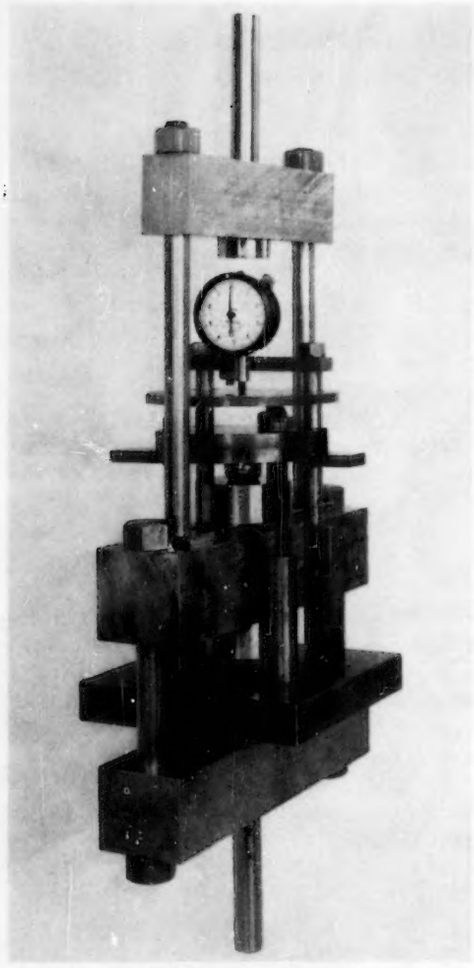


Fig. 3.—Arrangement for Calibration.

the length below the nuts when an assembly containing four $^1/_{16}$-in. gaskets is being tested. The second vertical scale shows the bolt load calculated to the area of a 1 by 2-in. gasket, which is the size regularly tested.

As explained above, stress-decay sets in the minute the screw jack ceases to operate. To get reproducible results we find it necessary to wait 1 hr. during which the stretch is restored several times to the specified value. By this time the rate of stress-decay has fallen off to a reasonable figure. As a further insurance, the apparatus is allowed to stand at room temperature for another hour and if the further stress-decay during this hour does not exceed 2 per cent of the original stress, the test is considered as off to a satisfactory start. The apparatus is then put in the oven for 22 hr. at the specified temperature, and the stress-decay read before removing the apparatus from the oven. This includes, of course, the small amount of stress-decay which occurred during the first hour at room temperature.

Although there is no question but that changes in the dial reading at room temperature are a faithful measure of stress-decay, some doubt may be expressed as to their validity at elevated temperatures. In the first place, the bolt calibration is changed, although this effect is undoubtedly small at the low oven temperatures employed, and does not affect the conclusions which are merely relative. More serious is the effect of thermal expansion of the stretched portion of the bolt; of the system comprising

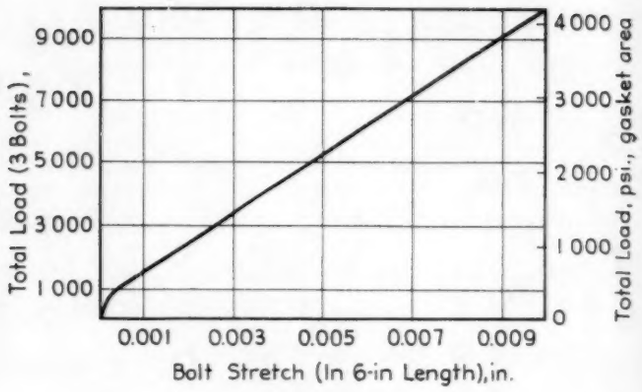


Fig. 4.—Bolt Calibration Curve.

the screw jack and flanges; and of the system comprising the dial gage supports, dial gage, bridge plate, and unstretched bolt ends. Since these are all of steel and all the same length, it might be assumed that expansion would be the same in all cases, and the dial gage reading would continue to reflect the extent of the bolt stretch and hence of the gasket stress. To test this theory, a test was run without any gaskets at a temperature of 158 F., and at an initial bolt stretch of 0.0023 in. corresponding to a gasket stress of 1160 psi. if gaskets had been present. The log of the early part of the test (Fig. 5) shows that there was some initial disturbance due, no doubt, to unequal rate of heating between flange assembly and dial-gage supports; after $1^1/_2$ hr., however, the dial returned to within 7 per cent of its original reading, retaining this error as long as the apparatus remained in the oven, but returning to the original reading when the apparatus cooled.

Since our stress-decay readings have all been taken with the apparatus still in the oven, it would have been proper to apply this correction; however, this was not done in the case of any of the tests subsequently reported, as it was felt that the results were of relative value only. The term "apparent stress-decay" might be more appropriate for the figures reported.

When gaskets are included there is a difference between the expansion of the gaskets and of an equivalent length of the bolts or dial-gage supports, which would tend to cause an initial increase in the gasket stress as the apparatus heats up. This effect, which is also present in the case of gaskets on commercial steam joints, is obscured, in our tests, by the variable metal expansion during the first

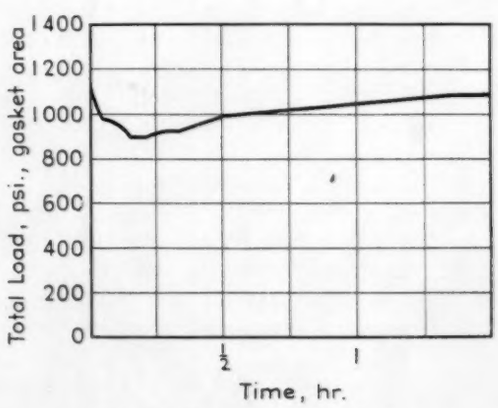


Fig. 5.—Test Without Gaskets.

1 1/2 hr., and thereafter by the normal stress-decay of the gasket. It probably does, however, serve to reduce the final stress-decay figure.

Regarding the accuracy of the instrument, the tests were, with a few exceptions, run in duplicate, and the resultant stress-decay measurements have in all cases checked to within 1 per cent. That is to say, if a stress-decay of 38 per cent is reported the individual tests have varied between 37 per cent and 39 per cent. A higher degree of accuracy could hardly be expected in view of the complexity of the factors influencing stress-decay.

For the series of tests about to be described, gaskets 1 in. in inside diameter and 2 in. in outside diameter were employed, all cut from a single piece of press-cured sheet 1/16 in. thick, except in the case of one series of tests in which other thicknesses were employed, but in these cases also the compound is believed to be identical. The compound is a relatively simple formula shown below:

Smoked sheets	100
Stearic acid	2
Zinc oxide	2.8
Agerite	1.0
Diphenylguanidine	1.9
Sulfur	2.6
Gastex	91
	201.3 parts by weight
Cure	30 min. at 292 F.
Tensile strength at 100 per cent elongation, psi	1150
200 per cent elongation, psi	2200
break, psi	2650
Elongation at break, per cent	280

No claim is made that this compound is especially heat resistant, as the purpose of these tests is to throw light on factors, which influence stress-decay, other than gasket properties.

Stress-decay is accompanied by contraction of the gasket in the thickness direction, with a corresponding increase in area. This increase in area can take place in either of two ways: (*a*) by lateral spread of the inner lamellae, the faces remaining stationary and anchored to their respective flanges, or (*b*) by slippage along the flange faces. It is important to know what happens because, in the one case, the remedy lies in an improvement in the properties of the compound, while in the other case, it is a property of the friction at the interface not affected in any way by the compound. Most writers on the subject seem to have assumed that stress-decay is the consequence of plastic flow in the gasket material, although the importance of frictional slippage in the compression performance of rubber cylinders has been pointed out many times, the most recent and complete discussion being that of Kimmich.[3]

A practical answer to the question might be given by using smooth flanges and lubricating, in one test, the faces of the gaskets with a glycerin-graphite grease, and, in the other case, leaving them dry. Unfortunately, we find that, even under 1160 psi. bolt load, which is the lowest we have employed in our tests, a 1/16-in. lubricated gasket compresses nearly 40 per cent initially, the effect being to cause the gaskets to be displaced laterally, and, in some cases, to be forcibly ejected from the joint during the course of tightening. It follows that, whatever might be the effect of lubricated surfaces on stress-decay, such an arrangement is of no practical value because, to lower the interfacial friction to such a low value is to invite a blowout. Many gasket failures have resulted from a too liberal application of gasket paste to both faces of the gasket.

The opposite type of test is to compare a gasket in contact with smooth, dry flanges with another gasket which is anchored to the flanges in such a way that no slippage is possible. The ideal way to accomplish the latter would be to vulcanize the gasket to the flange, but a good approximation and one more in accord with commercial practice is to employ a roughened flange. A popular type of surface is the so-called "phonograph finish" which is created by a continuous spiral cut made by a V-nosed tool on a 1/32-in pitch. We have two sets of such flanges; in the one, the cut is made to only about 0.002-in. depth; in the other to about 0.015-in. depth.

In the following, we tabulate the stress-decay values obtained for the three sets of flanges in tests each involving four 1 by 2 by 1/16-in. gaskets, after 22 hr. at 158 F. Initial gasket compressions are also shown.

Flanges	Smooth	Shallow Cut	Deep Cut
Bolt stretch, in.	0.0023	0.0023	0.0023
Corresponds to gasket load, psi.	1160	1160	1160
Same after oven test, average of two runs, psi.	705	910	1007
Decrease, per cent.	39	22	13
Initial compression, per cent.	10	15	27

It will be seen that the stress-decay in the case of the gaskets in contact with the deep-cut flanges is only one third of that with the smooth flanges. It follows that at least two thirds of the stress-decay experienced in the latter case may be attributed to frictional slippage as a primary cause, and not to "plastic flow" or any other property of the gasket compound, as is so frequently and incorrectly assumed. The performance of the "shallow cut" flange is intermediate, as would be expected. High initial compression in the case of the rough flanges is due to penetration of rubber compound into the grooves. One test in each of the first two pairs was prolonged for a total of 238 hr. in the oven with results as follows:

Flanges	Smooth		Shallow Cut	
Residual Load at End of	Load, per cent of Original	Rate of Change per hour, per cent	Load, per cent of Original	Rate of Change per hour, per cent
22 hr.	61.7	1.73	78.4	0.98
70 hr.	56.5	0.11	66.3	0.25
94 hr.	54.8	0.07	64.6	0.07
238 hr.	44.4	0.07	60.7	0.03

The rough flange is seen to have maintained its initial advantage, and apparently to be declining less rapidly at the finish. Extrapolating the curves to a base-line of 200 psi. gives 626 hr. for the smooth flange *versus* 1688 hr. for the shallow cut. If these gaskets were actually packing a pipe, and the pipe contained warm water at 200-lb. pressure, and no other effect intervened, such as the growth of the gasket to the flange, we should expect leakage to develop at these respective periods. The much longer life which the user can obtain with the same gasket by even a minor modification of the flange surface is clearly evident.

It may not be quite fair to extrapolate these curves to failure in the manner indicated, since the slopes were far from uniform, being marked by discontinuities caused in all probability by accidental jolts received by the apparatus. There is some evidence that, if the tests had been kept free from all vibration the residual stress might have

[3] E. G. Kimmich, "Rubber in Compression," ASTM BULLETIN, No. 106, October, 1940, p. 9.

substantially leveled off after 94 hr. In practice, however, there is no way of avoiding some vibration, and in all mechanical equilibria in which friction plays a part, the matter of vibration is very important. A test in which the flanges were continually pounded by an electric buzzer should give some very interesting results.

Another seemingly obvious way to postpone gasket failure is to start with a higher stress initially. The process, however, is seen to have limitations, since, if the crushing strength of the gasket were exceeded, "stress-decay" of the order of 100 per cent would occur immediately. To throw some light on this, the tests on smooth, shallow, and deep-cut flanges were repeated at higher initial loads. Results are tabulated in comparison with the tests already reported.

Load, psi.	Smooth		Shallow Cut		Deep Cut	
	Stress-Decay in 22 hr. at 158 F., per cent	Initial Compression, per cent	Stress-Decay in 22 hr. at 158 F., per cent	Initial Compression, per cent	Stress-Decay in 22 hr. at 158 F., per cent	Initial Compression, per cent
1160.....	39	10	22	15	13	27
2000.....	43	16	31	15	15	50
4000.....	46	26	38	20	22	53

Although in all three series of tests the stress-decay is higher for the heavier stresses, both absolutely and as a percentage, nevertheless the heavier loaded gaskets finish the test with higher absolute unit stresses, and are hence farther away from their failure point, unless, as seems unlikely, a longer test would show the curves as intersecting. The rough flanges are seen to exhibit their usual advantage over the smooth flange at all loads. It is evident that nothing resembling gasket crushing was experienced.

The compression figures are interesting as showing that, in the case of the shallow-cut flanges, the corrugations fill up with rubber at 1160 psi. but in the case of the deep-cut flanges the process is not complete until 2000 psi. At stresses above these, compression is presumably by lateral flow the same as with the smooth flanges, but inhibited by the firm anchorage of gasket to flange. Thus the additional compression between 2000 and 4000 psi. is seen to be less for the rough flanges.

There is also considerable diversity of opinion among flange engineers as to the proper thickness of gasket to employ. Admitting that the limitation to the use of a thinner gasket is the accuracy and degree of alignment of the flanges, the general opinion is that the thinnest gasket that can be used is the best. This conclusion, at least for roughened flanges, is supported by stress-decay data as follows (all tests at 1160 psi., 22 hr. at 158 F.):

Gasket Thickness, in.	Smooth		Deep Cut	
	Stress-Decay, per cent	Initial Compression, per cent	Stress-Decay, per cent	Initial Compression, per cent
1/32.....	38	9	5	47
1/16.....	39	10	13	27
1/8.....	40	18	29	26

The greatest benefit from the rough flanges as regards stress-decay is found with the 1/32-in. thick gaskets, nearly half the thickness being driven into the corrugations. As the thickness of the gasket increases in relation to the layer of "bound" rubber, the performance approaches that of a gasket between smooth flanges. In the case of the gaskets between smooth flanges, the initial compression increases with thickness, both absolutely and as a percentage, but there is not much difference in the stress-decay values for the different thicknesses.

Summarizing the above tests, maximum gasket load following stress-decay, and hence longest useful life in the case of a rubber gasket, is secured by:

1. Roughened flanges and absence of lubricating pastes.
2. High initial load short of the crushing strength of the material.
3. Thin gaskets.
4. (Probably) freedom from vibration.

Technical and Scientific Aids Sought by Federal Government

AN EXAMINATION has recently been announced by the Civil Service Commission to recruit technical and scientific aids for various Government agencies. Men and women are needed to do research and testing in radio, explosives, chemistry, physics, metallurgy, and fuels. The jobs pay from $1440 to $2000 a year.

Among the Government agencies that are expected to utilize the employment lists set up as a result of this examination are: Bureau of Agricultural Chemistry and Engineering, Department of Agriculture; Bureau of Mines, Department of the Interior; and the Bureau of Standards, Department of Commerce. The War and Navy Depts. also have vacancies—the War Dept. in its Quartermaster Corps, and the Navy Dept. in its laboratories.

No written test will be given to applicants. They will be rated on their education and experience as shown in their applications, subject to corroboration. Applicants must show 14 units of high-school study unless additional experience is substituted for it. In addition, they must have had appropriate technical and scientific experience of high quality. Approved defense training courses may be substituted for part, or—where appropriate—all, of the experience, and applicants having appropriate college study may utilize it for filling a major part of the experience requirement.

Applications will be rated as soon as possible after they are received at the Commission's Washington office until June 30, 1942. However, since many of these positions are connected with the National Defense Program, persons who are qualified for and interested in these positions are urged to apply at once. Full information, and application forms, may be obtained from the Civil Service Commission's representative at any first- or second-class post office, from the U. S. Civil Service Commission in Washington, D. C., or from any one of the Commission's district offices.

Then and Now

IN THE OLD DAYS if any one missed a stagecoach he had to wait two or three days for the next one, and usually was contented to do so. Now if any one misses one section of a revolving door he lets out a squawk. That's what progress has brought us.

Waverly *Kalends*

Studies of the Sulfate Resistance of Portland Cements

By G. Rupert Gause[1]

SYNOPSIS

A study has been made of the 106 portland cements on which Miller and Manson made comprehensive tests which they reported before the Society in 1940.[2] The present study was made upon 1:5 standard sand mortar specimens immersed in sodium sulfate solution. The relative resistance was determined by length-change measurements and by the time required to cause disintegration. The calculated tricalcium aluminate content of the cements gave the best indication of their resistance to the action of sulfates. The tricalcium aluminate content of the cement was better correlated with the resistance of the 1:5 mortar than it was with the resistance of the concretes tested by Miller and Manson.

MILLER AND MANSON'S studies of the sulfate resistance of cements[2] are the most comprehensive sulfate resistance studies that have been undertaken. These were made on 106 cements from which they rated the resistance upon the results of 3 series of tests on 2 by 4-in. concrete cylinders. The first series of cylinders was stored in Medicine Lake, S. Dak., the second series in a 1 per cent solution of magnesium sulfate ($MgSO_4$), and the third in a 1 per cent solution of sodium sulfate (Na_2SO_4). The compressive strengths of the first series of cylinders and the length increases of the other two series were the criteria used by them to rate the cements.

Miller and Manson furnished samples of these 106 cements to the National Bureau of Standards for tests to be decided upon by the Bureau. A proposed Federal Specification for sulfate-resistant cement was under consideration at the time these cements were received, and since a short-time test is required for the selection by specification of durable cements, it was decided that the tests of sulfate resistance should be made according to the method of the proposed specifications. The requirements (which were not adopted) of these specifications included the use of 1:5 mortar bars, cured 3 days, then immersed in a 10 per cent solution of Na_2SO_4, the length changes being determined at 28 days after preparation. In the present investigation the immersion and accompanying linear expansion measurements were continued for 5 yr. Similar measurements were also made on mortar bars which were cured for 7 days instead of 3 days, before immersion in the sodium sulfate solution.

TEST METHODS

The bars, 1 by 1 by 6 in., were made of a mortar of cement and standard Ottawa sand in the proportion 1:5 by weight, mixed with 9.3 per cent of water by weight of the dry materials. This amount of water was arbitrarily selected, since the limited quantities of the cement samples precluded making normal consistency tests, as required by the proposed Federal Specification. A brass machine screw with unslotted head was embedded in each end of the bar, the head of the screw being flush with the end of the bar. The plane surfaces of the heads were used as reference planes for measuring the lengths of the bars.

All of the bars were stored in the damp closet for 24 hr., after which they were separated into two sets. One set of bars, made in duplicate, and identified as 3-day-cured, represented the 96 cements received in the first lot. This set was stored under water for 2 days before being immersed in a 10 per cent solution of Na_2SO_4, individual containers being used. The other set of duplicate bars, identified as 7-day-cured, representing 102 out of the 106 cements, was stored under water for 6 days and then immersed in the sodium sulfate solution. At the end of a year all bars remaining intact were stored in two containers, one for each of the two sets described.

The lengths of the bars were measured to the nearest 0.0001 in. by means of a micrometer-dial comparator. The measurements of the bars, just before immersion in the sodium sulfate solution, were the "reference lengths" with which comparisons were made of changes recorded at various time intervals. The measurements were made at 28 days, as required by the specification, and, in addition, at 3 and 6 months, and 1, 2, and 5 yr. from the time of preparation of the bars.

RESULTS AND DISCUSSION

The data obtained on the 1:5 mortar bars and the ratings of the cements, which represent their relative resistance to sulfate action, are listed in Table I. The cements are arranged in the order of increasing $3CaO \cdot Al_2O_3$* content, as given in column 12. Columns 2 and 6 of the table give, respectively, the 28-day linear expansions of the 3- and 7-day-cured 1:5 mortars. In the proposed Federal Specification this expansion should not exceed 0.075 per cent in order that the cement be considered acceptable.

Linear expansions of the mortar bars immersed for 5 yr. in the sodium sulfate solution are given in columns 3 and 7 for the 3- and 7-day-cured bars, respectively. Where disintegration occurred in less than 5 yr. the number of weeks which had elapsed at the time when measurements could no longer be made, are listed. For such specimens the last measured expansions of the bars, before disintegration, were rather sharply defined, the bar either crumbling within a few weeks to a fine powder, or fracturing into large pieces.

Numerical values (columns 5 and 9, Table I) representing the relative sulfate resistance of the 1:5 mortar bars cured at 3 and 7 days were assigned as follows: Those bars which remained sound at the end of 5 yr. were as-

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 260 S. Broad St., Philadelphia, Pa.

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[2] Dalton G. Miller and Philip W. Manson, "Tests of 106 Commercial Cements for Sulfate Resistance," *Proceedings*, Am. Soc. Testing Mats., Vol. 40, p. 988 (1940).

* The $3CaO \cdot Al_2O_3$ values are those given by Miller and Manson. They were computed from the lime, alumina, silica, iron oxide, and free lime content, without consideration of the glass phase. For brevity $3CaO \cdot Al_2O_3$ will be written C_3A.

TABLE I.—DATA AND RATINGS OF MORTAR AND "CONCRETE" SPECIMENS.

Test	1:5 Mortar Bars									"Concrete" Rating (by Miller and Manson)	Tricalcium Aluminate Content, C_3A per cent	Miller and Manson Reference Number
	3-Day Damp Cured				7-Day Damp Cured				Final "Mortar" Rating			
	28-Day Linear Expansion, per cent	5-Year Linear Expansion, or Weeks to Disintegrate	Linear Expansion before Disintegration, per cent	Rating	28-Day Linear Expansion, per cent	5-Year Linear Expansion, or Weeks to Disintegrate	Linear Expansion before Disintegration, per cent	Rating				
1	2	3	4	5	6	7	8	9	10	11	12	13
No. 1	0.11	0.48%		17	0.03	200	0.05	15	16	8	0	628
No. 2	0.03	0.30%		7	0.03	0.57%		14	10	23	0.7	513
No. 3	0.03	0.46%		12	0.03	0.23%		5	9	14	2.2	507
No. 4	0.05	0.17%		1	0.03	0.40%		9	4	12	2.5	621
No. 5	0.03	0.47%		14	0.03	0.52%		11	14	15	2.9	605
No. 6	0.02	0.33%		8	0.01	0.05%		1	3	2	3.3	631
No. 7	0.02	0.20%		2	0.02	0.05%		2	1	3	3.5	531
No. 8	0.03	0.63%		19	0.03	0.23%		4	11	6	3.7	576
No. 9	0.04	250	0.79	25	0.03	100	0.33	19	23	5	3.9	591
No. 10	0.08	0.37%		10	0.12	0.55%		13	12	19	4.0	543
No. 11	0.03	0.32%		9	0.02	0.33%		8	8	7	4.1	426
No. 12	0.03	0.32%		6	0.02	0.33%		6	6	21	4.2	381
No. 13	0.15	0.37%		11	0.03	200	0.15	16	15	17	4.3	393
No. 14	0.05	50	0.57	28					29	40	4.8	471
No. 15	0.04	0.46%		13	0.04	0.50%		12	13	18	4.9	489
No. 16	0.02	0.21%		3	0.01	0.07%		3	2	4	5.1	405
No. 17	0.07	0.27%		5	0.03	0.33%		7	5	9	5.2	582
No. 18	0.14	0.53%		16	0.03	200	0.28	17	17	13	5.3	390
No. 19	0.03	0.26%		4	0.03	0.43%		10	7	1	5.4	611
No. 20	0.04	0.58%		15	0.02	200	0.43	18	18	26	5.4	396
No. 21	0.18	250	0.63	24	0.04	100	0.60	23	24	11	5.6	387
No. 22	0.04	24	0.25	35	0.03	24	0.32	28	31	22	5.6	608
No. 23[a]	0.06	0.57%		18					19	42	6.0	564
No. 24	0.05	48	0.21	29	0.03	52	0.03	27	28	45	6.0	408
No. 25	0.43	250	1.6	27	0.31	100	1.1	24	27	69	6.1	450
No. 26	0.09	250	1.00	26	0.04	76	0.04	25	26	16	6.2	561
No. 27	0.13	19	0.78	40	0.05	21	0.66	29	35	57	6.4	599
No. 28	0.07	36		30	0.05	14	0.50	39	34	10	6.7	596
No. 29	0.37	1.4%		23	0.05	100	0.39	20	21	25	6.7	534
No. 30	0.20	0.72%		20	0.14	100	0.53	22	20	29	6.7	528
No. 31	0.38	12	0.38	61	0.28	14	1.7	40	51	64	6.7	459
No. 32	0.40	24	0.75	36	0.30	16	0.29	36	39	52	6.8	453
No. 33	0.44	18	0.84	42	0.24	16	0.23	35	40	79	6.8	456
No. 34	0.06	28	0.65	31	0.04	20	0.27	30	30	24	7.1	441
No. 35	0.22	1.1%		22	0.27	100	0.48	21	22	28	7.2	540
No. 36	0.08	26	1.7	33	0.09	20	0.83	34	33	34	7.3	444
No. 37	0.20	0.72%		21	0.04	75		26	25	31	7.4	432
No. 38	0.44	24	0.91	38	0.13	20	0.75	33	37	27	7.5	519
No. 39	0.33	12	0.33	59	0.30	10	0.30	65	65	73	8.0	447
No. 40	0.21	14	0.92	45	0.05	12	0.05	41	42	44	8.4	624
No. 41	0.61	12	0.61	65	0.39	12	0.39	52	61	70	8.4	552
No. 42[a]					0.10	12	0.10	46	47	81	8.5	645
No. 43	0.14	12	0.14	52	0.09	12	0.09	45	50	48	8.6	510
No. 44	0.23	12	0.23	55	0.12	10	0.12	62	60	49	8.6	462
No. 45	0.19	12	0.19	54	0.09	11	0.09	54	56	59	8.6	402
No. 46	0.10	16	0.50	44	0.06	12	0.06	42	43	30	8.7	378
No. 47	0.25	12	0.25	56	0.20	11	0.20	56	58	65	8.8	423
No. 48	0.29	24	0.80	37	0.38	12	0.38	51	44	38	8.9	614
No. 49	0.06	16	0.42	43	0.50	15	1.0	38	41	32	9.0	486
No. 50	0.33	12	0.33	60	0.14	12	0.14	49	57	47	9.0	546
No. 51	0.12	12	0.12	48	0.06	10	0.06	59	55	53	9.0	399
No. 52	0.59	12	0.59	64	0.31	11	0.31	58	63	43	9.1	498
No. 53	0.46	19	1.10	41	0.25	12	0.25	50	46	58	9.1	549
No. 54	0.05	25	0.43	34	0.04	16	0.83	37	38	55	9.3	438
No. 55	0.46	8	0.46	82	0.11	8	0.11	72	79	78	9.3	627
No. 56	0.16	27	0.72	32	0.10	20	0.50	32	32	35	9.5	435
No. 57[a]					0.27	11	0.27	57	59	87	9.5	644
No. 58	0.14	12	0.14	50	0.07	12	0.07	44	48	95	9.5	668
No. 59	0.25	12	0.25	57	0.11	12	0.11	47	54	37	9.6	414
No. 60	0.11	10	0.11	68	0.11	10	0.11	61	68	39	9.6	474
No. 61	0.19	8	0.19	77	0.16	8	0.16	76	78	50	9.6	558
No. 62	0.23	10	0.23	69	0.20	9	0.20	66	70	63	9.6	619
No. 63	0.26	13	1.1	46	0.06	12	0.06	43	45	20	9.7	516
No. 64	0.44	20	0.69	39	0.37	20	0.34	31	36	36	9.7	525
No. 65	0.16	8	0.16	76	0.12	6	0.12	95	94	41	9.7	590
No. 66	0.13	12	0.13	49	0.07	11	0.07	53	52	46	9.7	384
No. 67	0.45	12	0.45	62	0.16	10	0.16	64	67	66	9.7	495
No. 68	0.29	7	0.29	86	0.06	10	0.06	60	72	62	9.8	492
No. 69	0.37	9	0.37	74	0.20	8	0.20	78	76	84	9.9	602
No. 70[a]					0.13	12	0.13	48	49	72	10.0	663
No. 71[a]	0.14	12	0.14	51					53	80	10.0	504
No. 72[a]					0.71	8	0.71	89	100	91	10.2	685
No. 73	0.20	11	0.20	67	0.10	11	0.10	55	64	33	10.3	570
No. 74	0.55	7	0.55	88	0.43	7	0.43	93	93	90	10.3	537
No. 75	0.25	10	0.25	70	0.14	10	0.13	63	69	60	10.4	465
No. 76[a]					0.18	8	0.18	77	80	82	10.4	641
No. 77[a]					0.35	8	0.35	86	95	83	10.5	656
No. 78	0.14	8	0.14	75	0.11	8	0.11	73	73	51	10.7	573
No. 79	1.12	6	1.12	94	0.40	5	0.40	100	103	104	10.8	630
No. 80	0.11	12	0.11	47	0.08	8	0.08	70	62	54	10.9	567
No. 81	0.42	8	0.42	80	0.15	8	0.15	73	77	56	10.9	555
No. 82	1.01	6	1.01	92	0.24	7	0.24	92	102	94	10.9	375
No. 83	0.59	7	0.59	89	0.16	8	0.16	75	89	61	11.0	501
No. 84[a]					0.46	8	0.46	88	98	85	11.0	650
No. 85	0.69	12	0.69	66	0.31	8	0.31	85	75	98	11.0	417
No. 86	0.63	8	0.63	84	0.28	8	0.28	84	91	71	11.3	420
No. 87	0.17	12	0.17	53	0.09	8	0.09	71	66	76	11.4	620
No. 88	0.25	8	0.25	78	0.20	7	0.20	91	92	99	11.4	632
No. 89	0.34	9	0.34	73	0.10	6	0.10	94	90	68	11.6	629
No. 90	0.47	8	0.47	83	0.20	8	0.20	80	87	89	11.6	579

[a] Insufficient cement for the preparation of both 3-day- and 7-day-cured mortar bars.

TABLE I.—(*Continued*).

Test	1:5 Mortar Bars									"Concrete" Rating (by Miller and Manson)	Tricalcium Aluminate Content, C_3A per cent	Miller and Manson Reference Number
	3-Day Damp Cured				7-Day Damp Cured				Final "Mortar" Rating			
	28-Day Linear Expansion, per cent	5-Year Linear Expansion, or Weeks to Disintegrate	Linear Expansion before Disintegration, per cent	Rating	28-Day Linear Expansion, per cent	5-Year Linear Expansion, or Weeks to Disintegrate	Linear Expansion before Disintegration, per cent	Rating				
1	2	3	4	5	6	7	8	9	10	11	12	13
No. 91	2.19	7	2.19	91	0.77	9	0.77	68	84	97	11.6	522
No. 92	1.29	7	1.29	90	0.70	9	0.70	67	82	106	11.7	483
No. 93[a]					0.20	8	0.20	79	83	74	11.8	669
No. 94	0.43	8	0.43	81	0.44	6	0.44	97	99	67	11.9	477
No. 95	0.42	10	0.42	71	0.25	8	0.25	83	81	93	11.9	411
No. 96[b]	dis.	4		95	1.1	5	1.1	101	104	102	12.0	468
No. 97	0.30	12	0.30	58	0.22	8	0.22	81	71	88	12.6	372
No. 98	0.30	8	0.30	79	0.17	6	0.17	96	97	92	12.6	595
No. 99	0.48	12	0.48	63	0.43	8	0.43	87	74	86	12.9	594
No. 100	0.83	8	0.83	85	0.47	6	0.47	98	101	100	13.3	429
No. 101[a]	0.44	7	0.44	87					96	96	13.4	480
No. 102	0.26	9	0.26	72	0.15	7	0.15	90	85	77	13.5	618
No. 103[a]					0.24	8	0.24	82	88	103	13.5	680
No. 104	1.07	6	1.07	93	1.1	9	1.1	69	86	101	13.8	593
No. 105[b]	dis.	4		96	dis.	4		102	105	75	14.1	615
No. 106[a]					0.70	6	0.70	99	106	105	14.2	662

[a] Insufficient cement for the preparation of both 3-day and 7-day cured mortar bars.
[b] Mortars had disintegrated at the end of 4 weeks, hence no expansion measurements were made.

signed consecutive numbers beginning with No. 1 in the order of the magnitude of their expansion at that age. Following this group the next higher number was given to the bar which required the longest period, short of 5 yr., to disintegrate. Where mortar bars made from different cements disintegrated at the same age, the ratings were made in the inverse order of expansion of such bars at the last measurement prior to disintegration. In the series of ratings, therefore, the low numbers indicate high sulfate resistance and the high numbers, low sulfate resistance.

The final ratings, given in column 10, Table I, were obtained by averaging the ratings of the 3-day and of the 7-day bars, arranging the resulting values in order and then numbering consecutively. Thus the cements rated 1 to 4 had 3-day and 7-day ratings, respectively, of 2 and 2, 3 and 3, 8 and 1, and 1 and 9. The 3- and 7-day ratings for those rated up to 45 are reasonably well correlated. Beyond this the relationship becomes more scattered.

For convenience in comparing the final ratings of the 1:5 mortar bars with the results obtained by Miller and Manson, their "concrete" ratings are given in column 11, and their corresponding cement reference numbers are listed in column 13.

The relationship between the ratings of the 1:5 mortar bars and those of the "concrete" cylinders is shown in Fig. 1. Although there is considerable scattering of points, a definite trend in their arrangement is indicated. In gen-

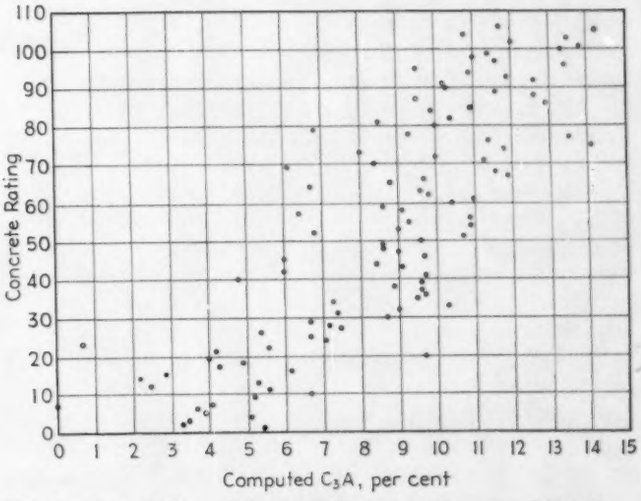

Fig. 2.—Correlation of Concrete Rating to Computed C_3A Content of the Cement.

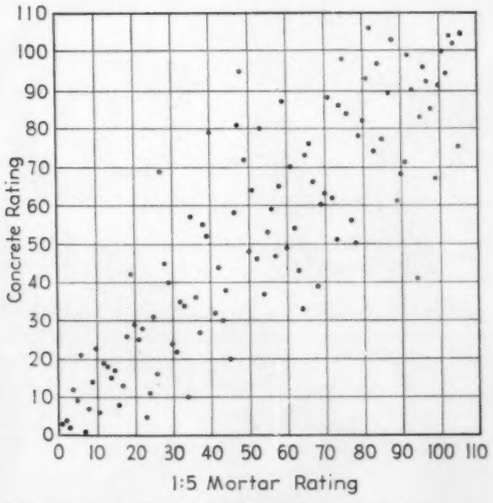

Fig. 1.—Comparison of Concrete and 1:5 Mortar Ratings of the Cement.

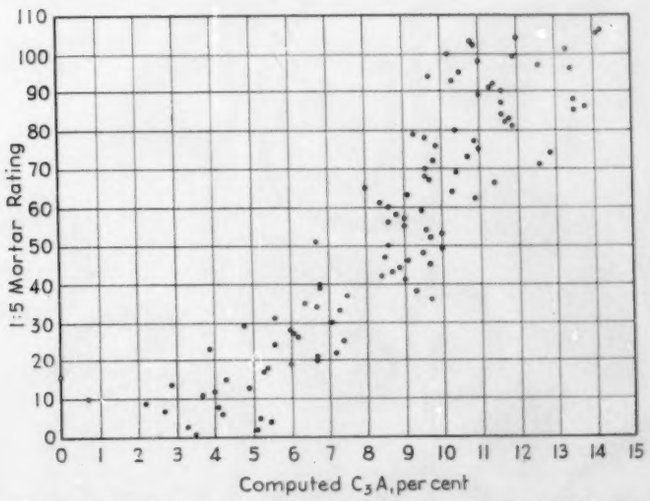

Fig. 3.—Correlation of 1:5 Mortar Rating to Computed C_3A Content of the Cements.

TABLE II.—"CONCRETE" RATINGS OF CEMENTS AS ESTIMATED BY FOUR CRITERIA.

Group	"Concrete" Rating[a]	With Expansion Less than 0.075 per cent	With C_3A Content Not More than		
			5 per cent	6 per cent	7 per cent
No. 1	1 to 10	9	6	9	10
No. 2	11 to 20	4	6	8	9
No. 3	21 to 30	5	2	4	6
No. 4	31 to 40	2	1	1	1
No. 5	41 to 50	2	0	2	2
No. 6	51 to 60	1	0	0	2
No. 7	61 to 70	0	0	0	2
No. 8	71 to 80	0	0	0	1
No. 9 to 11	81 to 106	0	0	0	0
Total		23	15	24	33

[a] These groups are made up by rearranging the "concrete" ratings in column 11, Table I, in their proper numerical order.

TABLE III.—1:5 MORTAR RATINGS OF CEMENTS AS ESTIMATED BY FOUR CRITERIA

Group	1:5 Mortar Rating, 3-day Cured[a]	With Expansion Less than 0.075 per cent	With C_3A Content Not More than		
			5 per cent	6 per cent	7 per cent
No. 1	1 to 10	9	7	10	10
No. 2	11 to 20	6	6	9	10
No. 3	21 to 30	4	2	4	8
No. 4	31 to 40	3	0	1	3
No. 5	41 to 50	1	0	0	1
No. 6	51 to 60	0	0	0	0
No. 7	61 to 70	0	0	0	1
No. 8	71 to 80	0	0	0	0
No. 9 to 11	81 to 106	0	0	0	0
Total		23	15	24	33

[a] These groups are made up by rearranging the ratings in column 5, Table I, in their proper numerical order.

eral, cements showing high mortar ratings also show high "concrete" ratings. There are, however, some notable exceptions. For example, the cements used in tests Nos. 58 and 63 (column 1, Table I) have final mortar ratings of 48 and 45 but "concrete" ratings of 95 and 20, respectively. Nevertheless if a certain limit be set to the concrete ratings, the preponderance of the mortar ratings of those same cements will be of equally good rating. For example, if we consider the twenty cements with a concrete rating of 20 or better, 15 will also have a mortar rating of 20 or better and none a worse rating than 40. Of those 20 cements with a mortar rating of 20 or better, 15 have a concrete rating of 20 or better and only one with a concrete rating as high as 42. The same approximate ratio of good to poor cements holds no matter what the limit we set, the ratio of poorer cements decreasing as the number accepted is increased.

Comparison of the relationships between the ratings obtained by the two test methods and the calculated C_3A contents of the cements is given in Figs. 2 and 3. A distinct trend, but considerable scattering of points is shown in Fig. 2; the relationship between calculated C_3A content and the mortar ratings given in Fig. 3 is much better.

There are several factors contributing to the differences exhibited by Figs. 2 and 3. First, the "concrete" cylinders were subjected to the action of solutions of magnesium sulfate as well as of sodium sulfate. It is known that the magnesium salt is capable of decomposing both hydrated calcium silicates and aluminates, whereas sodium sulfate attacks only the aluminates. Consequently a better correlation of rating with calculated C_3A content might be expected in Fig. 3 than in Fig. 2. A second factor is the high density of the "concrete" cylinders contrasted with the high porosity of the mortar bars. There is probably a much greater variation in the density of the "concrete" specimens made with different cements than in the density of the 1:5 mortar bars. The latter provided a relatively uniform structure throughout their mass for exposure of the cementitious material to attack by the sulfate solution. Another factor is the strength which the specimen has attained at the time the expansive forces induced by the sulfate solutions become significant. In the lean, porous, 1:5 mortar bars, the solutions make contact with the paste throughout the specimens before the latter have had time to develop an appreciable portion of their potential strength. In the concretes, on the other hand, hydration of the cements has proceeded unhindered for a considerably longer length of time before appreciable chemical action on the paste can begin. Considering the differences in experimental conditions, the agreement between the "concrete" and mortar ratings indicated in Figs. 1, 2, and 3 is better than might have been anticipated.

The calculated C_3A content furnishes an excellent criterion for rejection of poorly resistant cements. A limit of 5 per cent calculated C_3A, as incorporated in Federal Specification SS-C-211 for Sulfate-Resistant Cements and also by type V of A.S.T.M. Standard Specifications for Portland Cement (C 150 – 41),[3] rejects all cements with a concrete rating poorer than 40 and all but one with a rating of poorer than 23. The same limit rejects all with a 1:5 mor-

[3] 1941 Supplement to Book of A.S.T.M. Standards, Part II.

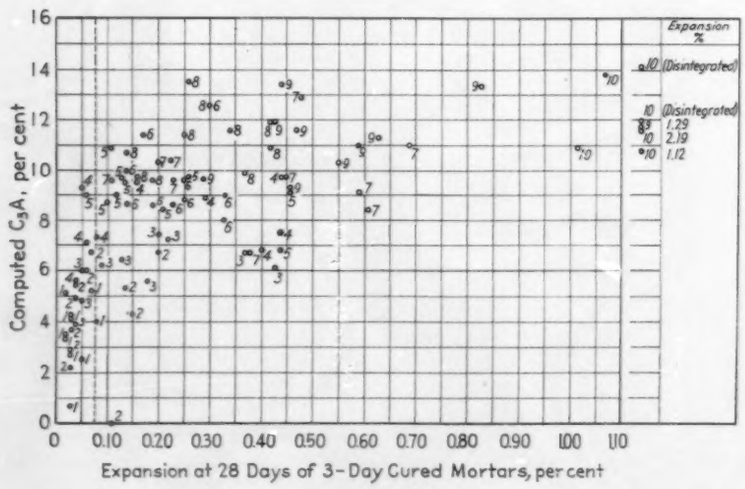

Fig. 4.—Relation Between Computed C_3A Contents of the Cement and the 28-day Expansion of the 3-day-Cured, 1:5 Mortars.

The numbers attached to the points indicate the group of Table III into which the cement falls. The dotted line indicates the limiting value of 0.075 per cent expansion.

tar rating poorer than 29, and all but two with a rating poorer than 16. However, in each case a large number of resistant cements are also rejected.

In Fig. 4 the 28-day linear expansions of the mortar bars, cured for 3 days, are plotted against the computed C_3A contents of the cements. The proposed Federal Specification would have limited the linear expansion at 28 days to 0.075 per cent. Points to the left of the dotted line in Fig. 4 represent cements conforming to this limitation. There is little relationship between the variables, the points being well scattered. The 0.075 linear expansion limitation does, however, limit the cements to those that are mainly very resistant. The poorest cement accepted had a rating of 45; of the 23 accepted, only [illegible] were rated poorer than 30. However, the criterion rejects 11 cements rated better than 30.

Tables II and III have been prepared to illustrate the cements that would be accepted by four criteria: a limiting linear expansion of 0.075 per cent, and limits of 5, 6, and 7 per cent for the calculated C_3A content. In Table II the cements are grouped in the order of their concrete rating and in Table III are grouped in the order of their 1:5 mortar rating. The selection of acceptable cements in either table is very close to the same distribution for each of the criteria. Thus a 5 per cent limit for the calculated C_3A content accepted six of those in the first ten by the concrete rating and six, two, and one in the second, third, and fourth groups. The same criterion of 5 per cent for the calculated C_3A content accepts seven, six, and two in the first, second, and third groups by the mortar rating.

By either method of rating, either the concrete or the 1:5 mortar, the 5 per cent limit for the calculated C_3A content is the most severe criterion. By either rating, the 0.075 per cent linear expansion and the 6 per cent limit for the calculated C_3A content are slightly less severe than the 5 per cent limit for the calculated C_3A content, and are approximately of equal severity, one to the other. In the mortar group the 7 per cent limit for the calculated C_3A content is just slightly less severe than the 6 per cent limit. On the other hand, if the concrete rating is the "standard" then the 7 per cent limit for the calculated C_3A content admits five more cements of poorer quality than those admitted by the 6 per cent limit.

The 5 per cent limit for the calculated C_3A content practically eliminates all cements of poor quality (with rating poorer than 30), but it also eliminates about as many resistant cements (of rating 30 or better). The other criteria accept more of the resistant cements, but, unfortunately, some of those that are not resistant. For example, the 7 per cent limit for the calculated C_3A, by "concrete" rating, accepts 25 of the first 30—but also accepts eight that are less resistant, seven of these in the groups from 41 to 80.

Summary and Conclusions

A rough agreement exists between the 1:5 mortar ratings and the ratings obtained by Miller and Manson (from their tests of 3 groups of 2 by 4-in. "concrete" cylinders stored in 1 per cent solutions of Na_2SO_4 and $MgSO_4$, respectively, and in Medicine Lake, S. Dak.). The agreement is better than might have been expected, however, since the 1:5 mortar bars were exposed to Na_2SO_4, whereas the concretes were also exposed to $MgSO_4$, which attacks different constituents.

The Miller and Manson ratings, obtained upon a dense concrete, would be expected to have a different order than the ratings obtained on the very porous 1:5 standard sand mortars. One factor is the difference in the salts to which they are exposed; another the great difference in density. The density of the concretes greatly slowed the penetration of the destructive salts to the interior of the specimen, which not only directly slowed the attack by the salt solution, but also gave additional time for the attainment of strength before attack.

Limitation of the calculated C_3A content of the cements, or of the 28-day linear expansion of the 1:5 mortar bars, will eliminate cements of poorer resistance to sulfate action. Limiting the calculated C_3A content to 5 per cent as required by Federal Specification SS-C-211 for Sulfate-resistant Cement and also by type V of A.S.T.M. Specification C 150 will eliminate all the poorly resistant cements but also eliminates as many resistant cements as are accepted. The limit of 0.075 to the 28-day linear expansion is approximately as rigorous as a limit of 6 per cent for the calculated C_3A content. Such a lessening of the rigor of the requirement, although eliminating fewer of the resistant cements, accepts a number of cements with poorer resistance.

Brazilian Papers on Engineering and Industrial Materials

Through the exchange relationship which the A.S.T.M. shares with engineering groups in other countries, publications of such groups are received in exchange for those of the A.S.T.M. They are available in the library at the Society Headquarters. Several papers, published as separate pamphlets printed in the Portuguese language, have recently been received from the "Instituto Nacional de Tecnologia," a Brazilian engineering society whose purpose is the development of knowledge of engineering and industrial materials. The subjects covered include the following: Some Applications of the Thermo-Balance; The Services of Laboratories to Construction Industries; Metallography of Aluminum Alloys; Two Summaries covering "Magnesia in Brazilian Cements," and "The Composition of Brazilian Cements"; Brazilian Specifications for Portland Cement and Modern Tendencies on the Subject; Diatomaceous Earth in Brazil; Soil Stabilization; Santa Catarina Coal; Licuri Waxes and Oils.

These publications are among the most recent which have been issued by this Brazilian organization. Some 70 pamphlets and reports have been published. Detailed information on these can be obtained by writing the Institute, Avenida Venezuela, 82, Rio de Janeira.

Stress-Strain Diagram of Malleable Cast Iron

By H. A. Schwartz[1] and C. H. Junge[1]

THE FORM OF THE stress-strain curve for malleable cast iron has been rather frequently investigated. Thomas Gray working at Rose Polytechnic about thirty-five years ago on test specimens of rectangular cross-section, 1/4 by 1 in., using the automatic stress-strain recorder of his own design, later manufactured by Riehle (Riehle-Gray), found a smooth curve. Robert McCormick working at Rose Polytechnic some fifteen years ago using the then standard A.S.T.M. specimen again obtained a smooth curve. The matter has been corroborated by the National Bureau of Standards' curves published in the Symposium on Malleable Cast Iron by the A.S.T.M. and A.F.A.[2] and by Landon's results in the 1940 A.S.T.M. *Proceedings*,[3] and probably by many others. All these investigations were conducted on unmachined specimens.

In connection with the work of the author on Young's modulus of elasticity presented at the 1941 Annual Meeting of the Society[4] it appeared well to investigate the form of the complete stress-strain curve. Since the modulus of elasticity cannot be satisfactorily determined on unmachined specimens, it seemed desirable for purposes of comparison to use machined specimens for the preparation of this stress-strain curve also even though an unmachined specimen is customarily used for acceptance testing. In that connection it was occasionally noted that the stress-strain curve had a somewhat unusual form as shown in Fig. 1. The curves *A*, *B*, and *C* of this figure are identical save for the scale used for strain. In about three-eighths of the cases observed there is a slight inflection which might almost be interpreted as a yield point.

This point is observed only on machined specimens the diameters of which at any section rarely varied by more than 0.0005 in. in a nominal 0.505-in. diameter and then only if the specimens are perfectly straight (not more than a few thousandths of an inch out of line at the center). It cannot be detected unless readings are taken at very close intervals, 0.002 in. per inch of strain or 250 psi. of stress. It is our impression that when it is not found the reason is that it is obscured (*a*) by lack of straightness, (*b*) by lack of uniformity of cross-section, and (*c*), most important of all, by the fact that the decarburized zone has a different stress-strain relation from the undecarburized zone causing the extensometer to read a sort of integration of many stress-strain relationships unless the decarburized zone has been completely removed. The existence of this point of inflection has been confirmed in the Cleveland laboratories of the Aluminum Company of America using the Templin autographic apparatus. They find this point with about the same frequency as we do.

Figure 1, already referred to, is typical of many such curves and is no doubt self-explanatory. To the best of our knowledge and belief unmachined specimens will never give this form of curve.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 260 S. Broad St., Philadelphia, Pa.

[1] Manager of Research, and Research Metallurgist, respectively, National Malleable and Steel Castings Co., Cleveland, Ohio.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part II, p. 317 (1931).

[3] R. D. Landon, "Stress-Strain Relations for Malleable Cast Iron in Tension with Special Attention to Yield Point Determination," *Proceedings*, Am. Soc. Testing Mats., Vol. 40, p. 849 (1940).

[4] H. A. Schwartz and C. H. Junge, "Young's Modulus of Elasticity and Some Related Properties of Graphitic Materials," *Proceedings*, Am. Soc. Testing Mats., Vol. 41 (1941).

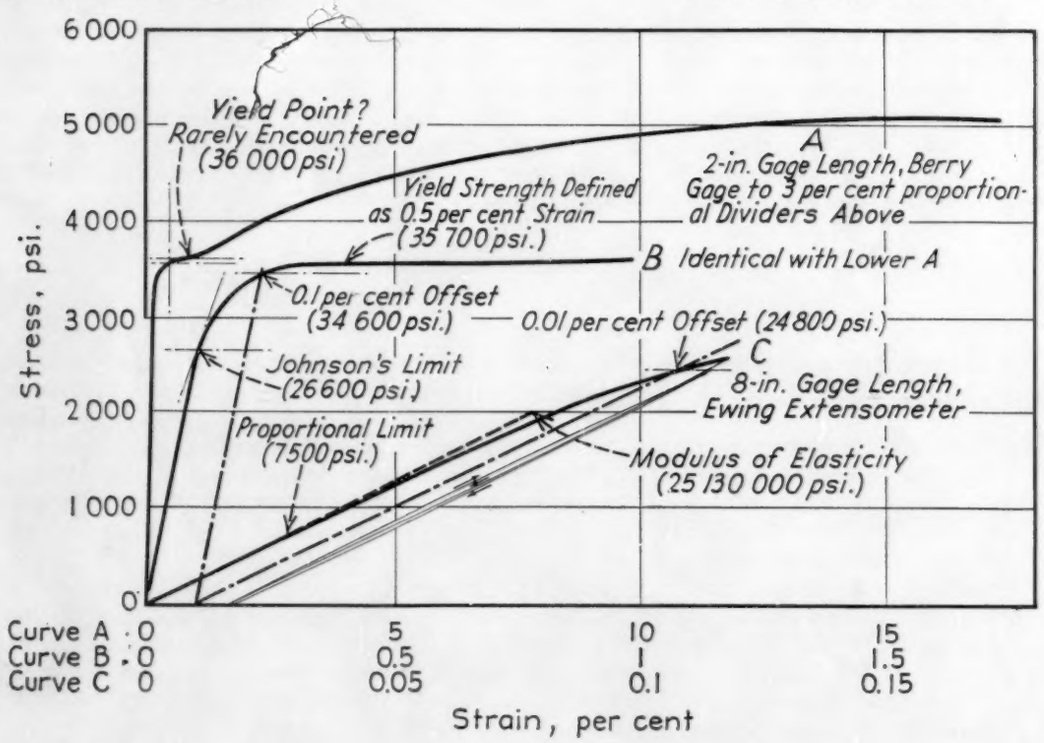

Fig. 1.—Stress-Strain Diagram of Malleable Cast Iron.

A Laboratory Test for the Ignitibility of Coal*

By Ralph A. Sherman,[1] J. M. Pilcher,[2] and H. N. Ostborg[3]

SYNOPSIS

This paper describes an extended investigation of the method and apparatus for the determination of the ignition temperature of solid fuels developed by the Coal Research Laboratory of Carnegie Institute of Technology. This method, like many others that have preceded it, is based essentially on the determination of the temperature at which the temperature in a bed of fuel crosses that of the furnace in which it is being heated in a current of air or oxygen. It differs, however, in that the rate of rise of the temperature of the sample at the crossing point is noted and the two are related by the Arrhenius equation for the dependence of the rate of reaction to the temperature.

The results are expressed as T_{15} and T_{75} which are the temperatures at which the temperature of the sample crosses that of the furnace when the rates of rise of the temperature of the sample are 15 and 75 C. per min., respectively. The data obtained in the investigation, principally on bituminous coals, show that variations in the rate of supply of oxygen or air, variations in the concentration of oxygen, variations in the rate of heating of the furnace, variations in the packing or in the height of the sample, or variations in the temperature of the furnace at the start of the test within rather broad limits do not materially affect the results. The size of the particles of the fuel investigated materially affects the results but for the same size of particle the method appears to measure an inherent characteristic of the different fuels. No predictions are made as to the utility of the data for application to sizes of coal as burned on grates but it is expected that this gap can be bridged.

ALL THOSE CONCERNED with the combustion of coal and coke have observed that different coals and cokes exhibit varying degrees of ease of ignition and many have suggested that a standard method for the determination of the ease of ignition or ignitibility or of the ignition temperature of coal and coke would be desirable and useful in the classification of fuels. The ignitibility and ignition temperature of a fuel may be defined in various ways, but for the purpose of this paper that which has been agreed upon by Subcommittee XVI on Ignitibility of Coal and Coke of the Society's Committee D-5 on Coal and Coke (*1*)[4] will be accepted. It is:

"The ignitibility of a fuel is that characteristic which determines the ease with which the fuel may be brought to a condition of self-supporting, active oxidation. The ignitibility is governed not only by the inherent chemical characteristics of the fuel that determine its rate of oxidation at various temperatures but also by the physical characteristics of the fuel and its surroundings that determine the rate at which it can be heated. Among these physical characteristics are (1) the size of the pieces of fuel, (2) the specific heat of the fuel, (3) the thermal conductivity of the pieces and of the aggregate, (4) the rate at which the oxygen or air is brought into contact with the fuel, and (5) the rate of heat loss to the surroundings. Chemical and physical changes, such as melting and decomposition of bituminous coal, may occur as the fuel is heated."

An ignition temperature of a fuel cannot, therefore, be considered an independent characteristic; but such a *temperature at which the rate of oxidation attains some definite value under standard conditions* may be a useful criterion of the performance of the fuel in combustion equipment.

Many workers have proposed apparatus and methods for the determination of the ignition temperatures of coal and coke. References to a number of these are included in the Bibliography (*2–24*). The majority have had the common feature that they passed air or oxygen through a bed of the fuel being heated with observation of the rate of increase of the temperature of the furnace and of the fuel. The measure of the ignition temperature has been variously that temperature at which the two temperature curves crossed or that temperature at which the rate of rise of the temperature of the sample reached some given value. Each worker or group has introduced certain modifications in the apparatus or method, and data showing the order of duplicability among different laboratories, which should be of high order for a method to be considered for a standard, have been lacking.

In discussion of the theory of the determination of the ignition temperature by the crossing point method, Sebastian and Mayers (*24*) have listed the following requirements of an apparatus:

"1. Sufficient oxygen must be supplied by the oxidizing gas stream so that its concentration throughout the coke column is effectively constant at the ignition point.

"2. The gas stream must reach the temperature of the coke charge before it comes in contact with it.

"3. The heat evolved must be immediately indicated by temperature rise and not be dissipated.

"4. The temperature of the coke should be uniform when the ignition point is reached.

"5. The curves representing coke and furnace temperatures must cross sharply enough to permit precise determination of the ignition temperature and of the time rate of increase of coke temperature."

These authors then describe an apparatus and method of calculation of the results that meet the specified conditions. They show that the crossing point and the rate of rise of the temperature of the fuel at the crossing point may be related by the Arrhenius equation for the dependence of reaction rates on temperature:

$$\log \frac{1}{p} \tan a = b - \frac{E}{4.575T} \qquad (1)$$

where p = partial pressure of oxygen,
$\tan a$ = slope at crossing point in degrees Centigrade per minute,

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* Presented at the Forty-fourth Annual Meeting, Am. Soc. Testing Mats., Chicago, Ill., June 23–27, 1941.

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[3] Research Engineer, Fuels Division, Battelle Memorial Institute, Columbus, Ohio.

[4] The italic numbers in parentheses refer to the reports and papers appearing in the Bibliography appended to this paper.

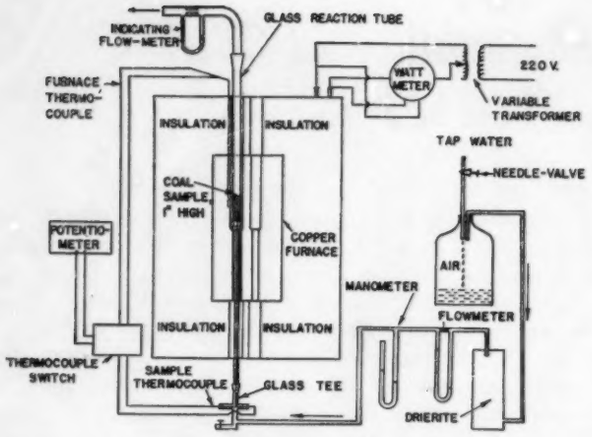

Fig. 1.—Diagram of C.R.L. Ignition Temperature Apparatus.

Fig. 2.—Two Ignition Temperature Furnaces as Set Up at Battelle.

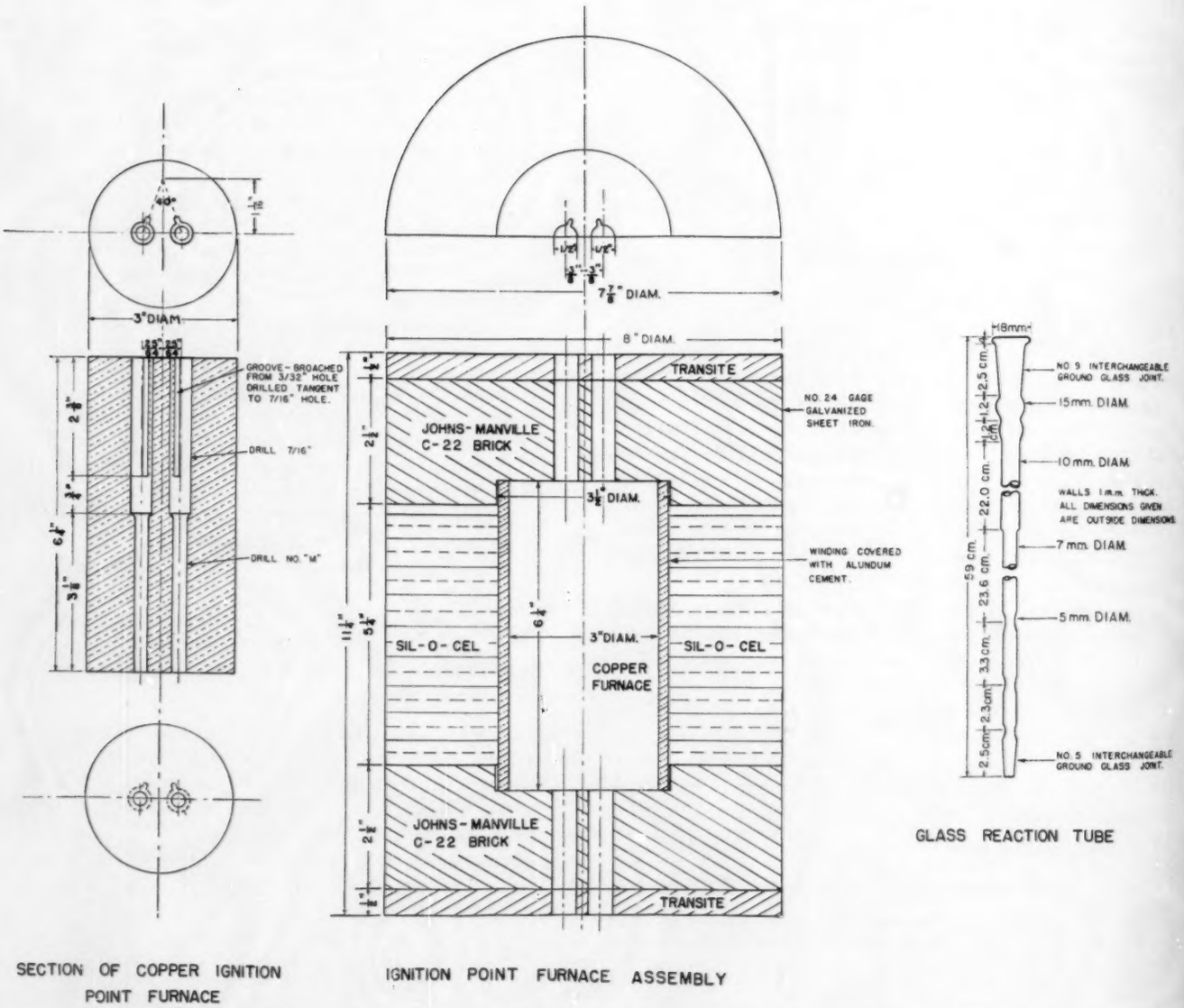

Fig. 3.—Dimensional Drawing of Copper Furnace, Assembly, and Reaction Tube.

b = empirical constant,
E = activation energy, and
T = absolute temperature in degrees Centigrade.

Because of the promise shown by this apparatus and method, the present investigation has been concerned with their trial with only such modifications as might simplify them but would not change their fundamental bases. Investigations have been made of the effect of variation in the rate of supply of oxygen or air, of changes in the partial pressure of the oxygen, of changes in the heating rate, of changes in the extent of packing of the sample, of the possibility of the use of minus 60 mesh coal or coke as used for other laboratory determinations, of the application of the method to coal as pulverized for firing under boilers, and of the relation of the specific surface of the coal to the ignition temperature.

Apparatus

Figure 1 shows schematically and not to scale the apparatus used; Fig. 2 shows the arrangement of the two furnaces and accessory equipment; and Fig. 3 includes scale drawings of the copper cylinder, its arrangement in the insulated jacket, and of the glass reaction tube.

The furnace is made of a cylindrical copper block bored with two holes for the glass reaction tubes alongside of which are grooves for the thermocouples by which the furnace temperatures are measured. The furnace is wound with 60 turns of No. 19 gage chromel-A resistance wire over two layers of $^1/_{32}$-in. asbestos paper, coated on the inside with a slurry of No. 563 alundum cement, wrapped tightly around the copper cylinder. To compensate for the heat loss from the ends of the furnace, the pitch is varied as follows:

First and sixth inch—12 turns per inch
Second and fifth inch—10 turns per inch
Third and fourth inch—8 turns per inch

A coating of alundum cement covers the windings. Their total resistance, including the leads, is 24 ohms.

The thermocouples are No. 28 gage chromel-P and alumel wire mounted in 2.0-mm., outside diameter, two-hole porcelain tubing. The bead of the thermocouple for measurement of the furnace temperature is turned to bear against the glass reaction tube. The thermocouple for measurement of the temperature of the sample is inserted through the lower part of the reaction tube with the leads brought out through the legs of the glass Tee. The junction extends $^1/_{16}$ in. beyond the end of the porcelain tube. One-half inch below the tip of the thermocouple a strip of No. 52 mesh platinum wire gauze $^1/_4$ in. wide is wound around the porcelain until it fits closely in the glass tube. This serves as a support for the sample. As enough sample is used to make a column 1 in. high, the junction of the thermocouple is in the center of the sample.

Air is supplied to the sample in one reaction tube and oxygen to the other at constant rates. Air is supplied from a 3-gal. bottle by displacement with tap water whose flow is controlled by a needle valve. Oxygen is supplied directly from the oxygen cylinder as experiment proved that storage over water resulted in an appreciable change in the oxygen concentration. Both gases are passed over Drierite and through capillary flowmeters for determination of the rate of flow; a capillary 0.5 mm. in diameter and 10 cm. long is suitable for the rates of flow used. A second manometer in each line indicates the static pressure required to force the gas through the sample. On top of each reaction tube is placed an indicating flowmeter to check whether leakage has occurred in any part of the system.

A continuously variable transformer is a convenient means for variation of the rate of heating of the furnace. A wattmeter with a maximum range of 1000 w. is desirable. For coal, a suitable rate of heating is obtained with an input of 650 w.; for coke, 1000 w. are to be preferred.

Test Procedure

Two determinations are normally made simultaneously in one furnace. Duplicate samples of the fuel, to the depth of 1 in., are placed in the reaction tubes. The sample is packed in the tube by dropping a glass rod, 0.7 cm. in diameter and 35 cm. long, weighing 31 g., three times onto the sample from a height of 8 cm. Air is passed through one at a rate of 85 ml. per minute and oxygen through the other at 50 ml. per minute. After the electric current is turned on, four temperature readings, of the sample and of the furnace for each reaction tube, are made at 15-sec. intervals. The temperature at each position is thus recorded every $1^1/_2$ min. The variable transformer is adjusted as required to maintain a constant wattage input to the furnace and the flowmeters are observed and valves adjusted to maintain constant rates of gas flow.

At the close of a determination, it is not necessary to dismantle the apparatus to remove the sample as this may be conveniently done as follows: The tube with indicating flowmeter at the top of the reaction tube is replaced by a right-angle tube over the end of which a crucible or beaker may be held to catch the sample. A stopcock, not shown, in the tube leading the air or oxygen to the bottom of the reaction tube is closed and a tube connected to a source of compressed air is connected to the Tee at the extreme bottom of the reaction tube; this Tee is normally closed by means of a short length of rubber tubing and pinch clamp. The sample is thus blown out by compressed air. Enough slack is left in the thermocouple wires and other connections that the reaction tube may be lifted from the furnace far enough to see whether the sample is completely removed. If it should coke and adhere to the glass, a small brush may be inserted from the top to loosen the coke.

Method of Calculating Ignition Temperatures

As previously defined, the ignition temperature of a fuel is the temperature of crossing of the furnace and sample temperatures when the rate of rise of the temperature of the sample reaches some specified value. Because the rate of heating of the furnace necessary to obtain a given rate of rise of the temperature of the sample at the crossing point cannot be predicted in advance, the logarithms of the rates of rise obtained in the determination, divided by the partial pressure of the oxygen, are plotted against the reciprocal of the absolute temperature of the crossing points. The temperature for any given rate of rise may then be interpolated on the straight-line curve.

Because a convenient rate of heat input to the furnace gives for average coals a rate of rise of approximately 15 C. per minute in oxygen or air and because the latter becomes approximately 75 C. per minute when corrected for the partial pressure of the oxygen in air, 1/0.209, Sebas-

TABLE I.—DATA SHEET FOR C.R.L. IGNITION POINT DETERMINATION USING GRAPHICAL METHOD.

Run No. 107
Sample Pittsburgh Seam Coal
Watts to furnace No. 2 = 700 w.
Rate of oxygen flow = 50 ml. per min.
Rate of air flow = 85 ml. per min.
Barometric pressure = 29.29 in. Hg
Line voltage = 220 v.

Date, December 29, 1939
Size, 40–60 mesh
Sample weight = 0.870 g.
Centimeter head = 11.5 (No. 3)
Centimeter head = 7.7 (No. 1)
Room temperature = 22 C.
Furnace voltage = 135 to 137 v.

Millivolt Readings					Time, min.	Corrected, mv.		Temperature, deg. Cent.[a]	
Time, min.	Position 8 Sample Oxygen	Position 9 Furnace Oxygen	Position 10 Sample Air	Position 11 Furnace Air		Sample	Furnace	Sample	Furnace
					Sample in Oxygen				
0	0.93	0.93	0.93	1.06	13.5	...	7.28	....	178.75
3	1.44	2.11	1.62	2.28	15.0	7.41	7.97	182.0	196.0
6	2.75	3.61	3.03	3.79	16.5	8.25	8.67	203.0	213.5
7.5	3.55	4.42	3.80	4.81	18.0	9.21	9.41	227.0	231.75
9	4.35	5.20	4.62	5.48	19.5	10.52	10.09	259.0	248.75
10.5	5.12	5.97	5.43	6.23	21.0	13.28	10.83	326.0	266.75
12	5.94	6.71	6.18	6.96					
13.5	6.72	7.42	6.98	7.69	Sample in Air				
15	7.55	8.12	7.75	8.38					
16.5	8.40	8.82	8.50	9.09	17.0	...	8.93	....	220.0
18	9.37	9.57	9.28	9.80	18.5	9.12	9.64	224.75	237.5
19.5	10.69	10.26	10.08	10.49	20.0	9.91	10.32	244.25	254.25
21	13.47	11.00	10.92	11.17	21.5	10.75	11.00	264.75	270.75
22.5	...	...	11.92	11.82	23.0	11.74	11.64	288.75	286.25
24	...	...	13.01	12.51	24.5	12.82	12.33	315.0	303.0

Time interval between successive temperature readings is 15 sec.

Check on Gas Flow Rate by Water Displacement

	Original		Final		Difference		Rate, ml. per min.
	Reading, liters	Time, min.	Reading, liters	Time, min.	Reading, liters	Time, min.	
Oxygen	0.70	0	1.75	21.25	1.05	21.25	49.4
Air	0.80	0	2.80	24.75	2.00	24.75	80.8

[a] Temperature reported to nearest 0.25 C.

tian and Mayers (*24*) of the Coal Research Laboratory of Carnegie Institute of Technology have adopted the practice of expressing the results as T_{15} and T_{75} which are the crossing points or ignition temperatures when the rates of rise of the temperature of the sample are 15 and 75 C. per minute, respectively. The authors have adopted a similar practice and nomenclature.

Sebastian and Mayers (*24*) have presented an analytical method developed by Landau for determining the crossing point and slope of the temperature of the sample from the experimental data. This was tried by the authors, but was rejected in favor of a graphical method because the latter required less time and was less subject to the arithmetical errors possible with the analytical method.

Table I shows the data recorded during a typical determination of the ignition temperature. The two columns on the right show the temperatures near the crossing points that are used in the graphical solution of the crossing point.

Figures 4 and 5 show how the data of Table I are plotted to obtain the crossing points and slopes in oxygen and air, respectively. The data are plotted to such a scale that the temperatures and crossing points can be read to the nearest quarter degree Centigrade. Figure 6 shows how the logarithms of the slope, divided by the partial pressure of the oxygen, obtained from Figs. 4 and 5, are plotted against the reciprocals of the absolute temperature to obtain the values for T_{15} of 227 C. and for T_{75} of 275 C. The activa-

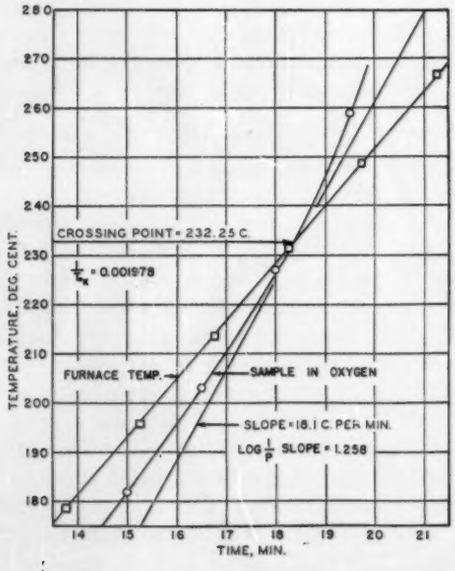

Fig. 4.—Graphical Solution of Crossing Point for Test Run No. 107—Pittsburgh Seam Coal in Oxygen Atmosphere.

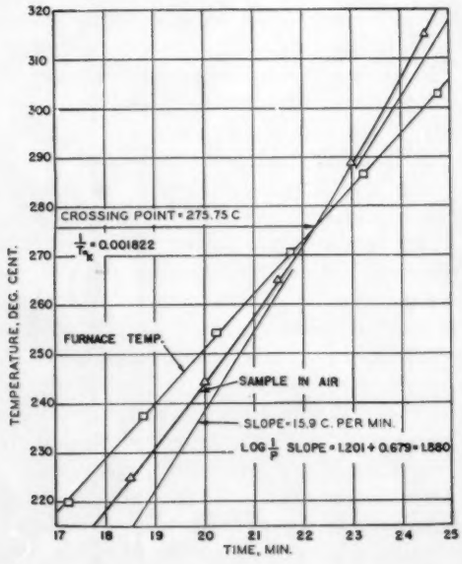
CROSSING POINT = 275.75 C
1/Tx = 0.001822
FURNACE TEMP.
SAMPLE IN AIR
SLOPE = 15.9 C. PER MIN.
LOG 1/P SLOPE = 1.201 + 0.679 = 1.880
TEMPERATURE, DEG. CENT.
TIME, MIN.

Fig. 5.—Graphical Solution of Crossing Point for Test Run No. 107—Pittsburgh Seam Coal in Air Atmosphere.

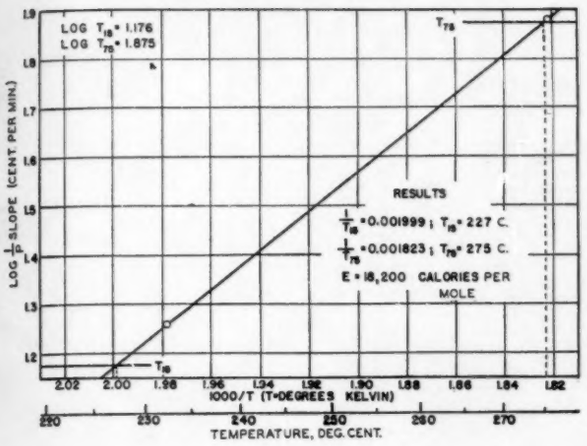
LOG T_{15} = 1.176
LOG T_{75} = 1.875
T_{75}
RESULTS
$\frac{1}{T_{15}}$ = 0.001999 ; T_{15} = 227 C.
$\frac{1}{T_{75}}$ = 0.001823 ; T_{75} = 275 C.
E = 18,200 CALORIES PER MOLE
T_{15}
LOG $\frac{1}{p}$ SLOPE (CENT. PER MIN.)
1000/T (T=DEGREES KELVIN)
TEMPERATURE, DEG. CENT.

Fig. 6.—Graphical Solution of T_{15} and T_{75} for 40–60 Mesh Pittsburgh Seam Coal.

tion energy, E in Eq. 1, is calculated as 18,200 cal. per mol for the particular sample as follows:

$$E = \frac{3.198}{\frac{1}{T_{15}} - \frac{1}{T_{75}}} \text{ cal. per mol} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Discussion of Experimental Results

Approximately 300 determinations have been made. Most have been on bituminous coals but a few cokes have been included. Systematic investigations have been made of numerous factors that might affect the results obtained.

Effect of Variation in Rate of Supply of Air or Oxygen to Sample

One of the stated requirements of this method is that enough oxygen should be supplied to the sample that its concentration is effectively constant throughout the sample at the ignition point, but not so high that appreciable amounts of heat are removed from the sample.

Figure 7 shows how the crossing points varied for samples of 40–60 mesh Pittsburgh seam coal with rates of flow of oxygen and air well below and above the rates of 50 ml. and 85 ml. per minute, respectively, which were

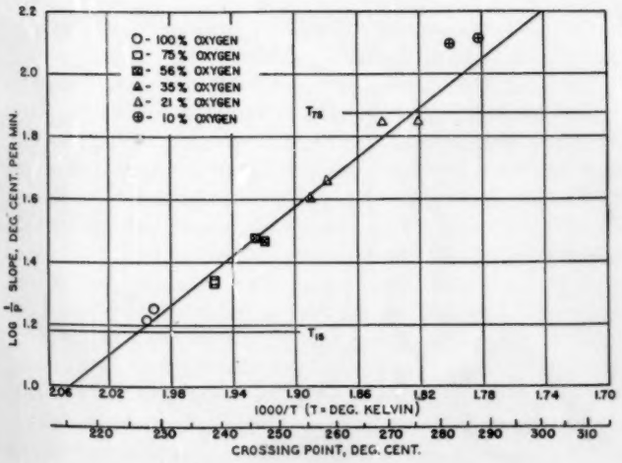
O - 100 % OXYGEN
□ - 75 % OXYGEN
⊠ - 56 % OXYGEN
▲ - 35 % OXYGEN
△ - 21 % OXYGEN
⊕ - 10 % OXYGEN
T_{75}
T_{15}
LOG $\frac{1}{p}$ SLOPE, DEG. CENT. PER MIN.
1000/T (T = DEG. KELVIN)
CROSSING POINT, DEG. CENT.

Fig. 8.—Results of Tests on 40–60 Mesh Pittsburgh Seam Coal Using Varying Percentages of Oxygen.

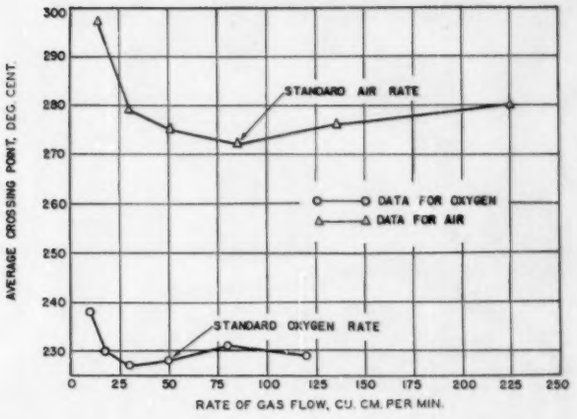
STANDARD AIR RATE
O—O DATA FOR OXYGEN
△—△ DATA FOR AIR
STANDARD OXYGEN RATE
AVERAGE CROSSING POINT, DEG. CENT.
RATE OF GAS FLOW, CU. CM. PER MIN.

Fig. 7.—Effect of Oxygen and Air Rate on Crossing Point.

chosen by the Coal Research Laboratory as suitable rates. It is seen that the variation is greater in air than in oxygen but that the rates chosen by Sebastian and Mayers are entirely suitable for bituminous coal. It is also seen that small changes on either side of these rates will not make large differences in the results.

Effect of Variations in Oxygen Concentration

The interpolation shown in Fig. 6 to obtain values for T_{15} and T_{75} assumes a linear relation between log $(1/p)$ tan a and the reciprocal of the absolute temperature of the crossing point. For purpose of confirmation of the findings of the Coal Research Laboratory that this relation held, a series of determinations was made on 40–60 mesh Pittsburgh seam coal with the gas stream containing from 10 to 100 per cent oxygen.

Figure 8 shows that all the points except those using 10 per cent oxygen fall satisfactorily close to the straight line.

Effect of Variations in Rate of Heating

Figure 9 shows the results of determinations on the same 40–60 mesh Pittsburgh seam coal when the heating rate was varied from 100 w., 1.3 C. per min. rise in furnace

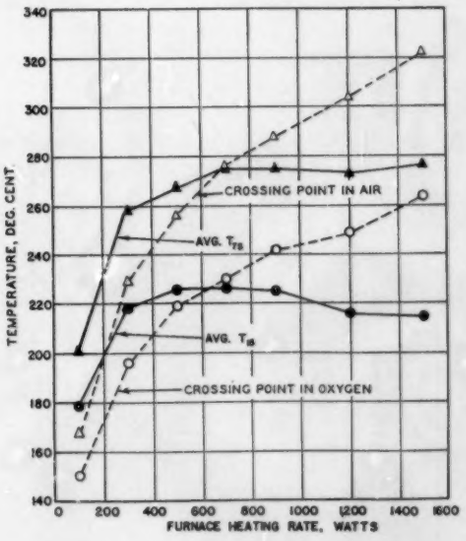

Fig. 9.—Results of Tests on 40–60 Mesh Pittsburgh Seam Coal Using Various Heating Rates.

TABLE II.—RESULTS OF IGNITION TESTS ON 40–60 MESH PITTSBURGH SEAM COAL SAMPLES PACKED TO VARYING EXTENTS.

Test	Extent of Packing	Sample in Oxygen			Sample in Air		
		Crossing Point, deg. Cent.	Slope, deg. Cent. per min.	T_{15}, deg. Cent.	Crossing Point, deg. Cent.	Slope, deg. Cent. per min.	T_{75}, deg. Cent.
No. 148	None	225	15.9	224	268	13.3	274
No. 149	None	226	16.6	223	268	13.3	274
Avg.	None			*224*			*274*
No. 150	Slight	222	15.5	221	265	13.3	270
No. 151	Slight	222	16.0	220	264	13.7	268
No. 162	Slight	226	16.4	223	266	13.3	271
No. 163	Slight	226	15.9	224	268	13.8	272
Avg.	Slight			*222*			*270*
No. 5	Normal	229	17.8	224	276	14.6	279
No. 6	Normal	228	16.4	226	269	14.5	272
Avg.	Normal			*225*			*276*
No. 156	Excessive	224	15.8	222	272	13.7	277
No. 157	Excessive	224	16.2	221	266	13.3	272
Avg.	Excessive			*222*			*275*

temperature, to 1500 w., 24 C. per min., using both air and oxygen at each rate of heating. With the exception of the two heating rates below 500 w., the values of T_{15} and T_{75} remain reasonably constant as the heating rate is increased, although the crossing points vary continuously.

Effect of Packing and Height of Sample

To determine the effect of the degree of packing of the sample in the reaction tube, four series of tests were made on 40–60 mesh Pittsburgh seam coal with varying degrees of packing: (1) no packing, (2) slight packing, (3) normal packing, and (4) excessive packing. In normal packing, a glass rod, 0.7 cm. in diameter and 35 cm. long, weighing 31 g., is dropped ten times from a height of approximately 8 cm. onto the sample in the tube. For slight packing, the rod was dropped only twice, and for excessive packing the rod was dropped forty times.

Table II presents the results obtained. The close agreement of duplicates under each condition and of the averages for the several conditions show that the extent of packing within the rather wide limits used makes no essential difference in the results obtained.

To determine the effect of change in the height of the sample below and above the standard of 1 in. normally used, determinations were made with sample heights of 0.75 and 1.5 in. also. The tip of the thermocouple for measurement of the temperature of the sample was left at $^1/_2$ in. above the bottom of the sample in all tests.

Table III presents the results obtained. Again the close agreement shows that the height of the sample is unimportant within these limits and it is unnecessary to weigh the sample used.

TABLE III.—RESULTS OF IGNITION TESTS ON 40–60 MESH PITTSBURGH SEAM COAL SAMPLES OF VARYING HEIGHTS.

Test	Sample Height, in.	Sample in Oxygen			Sample in Air		
		Crossing Point, deg. Cent.	Slope, deg. Cent. per min.	T_{15}, deg. Cent.	Crossing Point, deg. Cent.	Slope, deg. Cent. per min.	T_{75}, deg. Cent.
No. 191	0.75	226	16.3	224	269	13.7	274
No. 192	0.75	224	16.9	221	265	12.9	272
Avg.	0.75			*223*			*273*
No. 5	1.0	229	17.8	224	276	14.6	279
No. 6	1.0	228	16.4	226	269	14.5	272
Avg.	1.0			*225*			*276*
No. 193	1.5	226	17.0	222	273	13.9	277
No. 194	1.5	226	16.4	223	268	13.8	273
Avg.	1.5			*223*			*275*

TABLE IV.—IGNITION TEMPERATURES OF MINUS 60 MESH PITTSBURGH AND POCAHONTAS NO. 3 SEAM COALS, PREPARED IN FIVE TYPES OF CRINDING EQUIPMENT.

Equipment	Minus 200 Mesh, per cent	Specific Surface, sq. cm. per g.	T_{15}, deg. Cent.	T_{75}, deg. Cent.
Pittsburgh Seam Coal				
Roll crusher	27.8	1280	188	220
Electric coffee mill	30.3	1760	188	220
Hand coffee mill	33.8	1940	188	213
Bucking board	36.5	2220	184	211
Disk grinder	36.8	2260	187	215
Pocahontas No. 3 Seam Coal				
Roll crusher	28.7	1480	213	244
Electric coffee mill	29.8	1810	210	236
Hand coffee mill	39.0	2530	209	236
Bucking board	40.6	2630	212	234
Disk grinder, 1	55.2	3870	210	226
Disk grinder, 2	54.0	3530	208	225

Use of Samples Passing No. 60 Sieve

As with any other characteristics of a sample of coal, the ignition temperature should be that of the entire sample, but in the preparation of a sample passing the 40 mesh and remaining on the 60 mesh sieves, approximately one half of the coal must be discarded as minus 60 mesh coal despite careful stage grinding. For this reason, a sample of such close size limits cannot be truly representative of the original sample of coal. To avoid this difficulty, samples passing the No. 60 sieve can be prepared for the determination as for other laboratory tests on coal. Several alternative methods for preparation of a minus 60 mesh sample are available and as the amount of fine grinding and total surface produced is likely to vary with the different methods, data were obtained with two coals, one hard and the other soft, for the ignition temperatures with five methods of preparation of the sample from an original sample passing the No. 4 sieve.

The five methods used were: (1) An electric coffee mill, (2) a hand coffee mill, (3) the bucking board, (4) a roll crusher using stage crushing, and (5) a disk grinder. Table IV presents the results obtained for T_{15} and T_{75}, the percentage passing No. 200 sieve, and the specific surface in square centimeters per gram. The surface was determined by the air permeability method as described by Lea and Nurse (*26*).

The procedure in making these tests was changed from that for the 40–60 mesh samples as follows: A $^1/_8$-in. layer of 40–60 mesh carborundum was placed on top of the sample and a porous plug $^1/_4$ in. high and 7 mm. in diameter was held on top of the sample by a weight of 37.5 g. placed on a piece of porcelain tubing.

The data obtained on the two coals show that despite rather wide differences, for the samples prepared by the five types of equipment, in the percentage passing No. 200 sieve and in the specific surface—almost three to one for the Pocahontas coal—the ignition temperatures were not greatly different. The differences were greater for T_{75} than for T_{15}, a maximum of 9 deg. for Pittsburgh coal and 19 deg. for Pocahontas coal. The two samples of the latter coal prepared by the disk grinder were prepared because of the particularly low result for T_{75} on the first sample prepared. The second sample prepared by a second operator checked substantially with the first, in percentage passing a No. 200 sieve, in specific surface, and in ignition temperatures. All ignition temperatures given in Table IV are the average of two determinations.

These results indicate that samples for the determina-

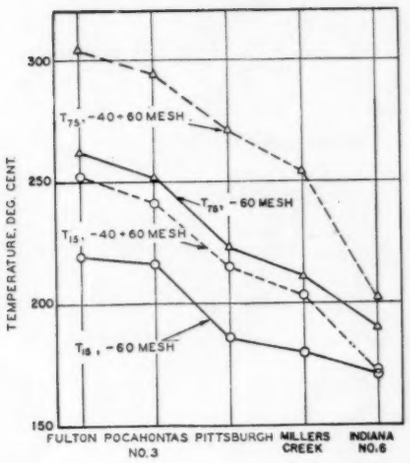

Fig. 10.—Results of Ignition Tests on Minus 60 Mesh Coals Compared with Tests on the 40–60 Mesh Size.

tion of the ignition temperature may be safely prepared in the standard equipment by which minus 60 mesh samples are normally prepared for other laboratory determinations on coal if care is taken to use stage grinding and avoid the excessive production of fines.

Figure 10 shows for a few typical coals a comparison of the values obtained for T_{15} and T_{75} with 40–60 mesh and minus 60 mesh coals. As would be expected from the difference in the specific surface of the two sizes of coal, the ignition temperatures were found to be lower for the minus 60 mesh coal; the difference amounted to as much as 33 deg. for T_{15} and 48 deg. for T_{75}. Little difference was found for the Indiana No. 6 coal which had the lowest ignition temperature of the five coals shown.

Application of Method to Pulverized Coal

The ignition temperature of coal would appear to be particularly important when the coal is burned in pulverized form. Two factors may affect the ignition temperature of a given coal, the inherent characteristics of the coal, and the size to which it is pulverized for firing. If coal as pulverized for firing in industrial furnaces or boilers could be used in the laboratory apparatus described, it would enable a direct comparison of the ignition characteristics of given coals.

Two difficulties were encountered in the first attempts to use pulverized coal in the equipment: (1) The static pressure required to pass the desired volume of air or oxygen was high, and (2) the bed was unstable and fine material was blown from it. To overcome these difficulties, the same measures used with minus 60 mesh coal were employed and, in addition, a $^1/_8$-in. layer of carborundum was placed below the sample, the height of the sample was reduced to $^3/_4$ in., and the weight on top was increased to 160 g.

TABLE V.—RESULTS OF IGNITION TESTS ON PULVERIZED AND 40–60 MESH COALS.

Coal	Minus 200 Mesh, per cent	Specific Surface of Pulverized Coal, sq. cm. per g.	T_{15}, deg. Cent.		T_{75}, deg. Cent.	
			Pulverized	40–60 Mesh	Pulverized	40–60 Mesh
C Prime	75.0	4060	205	241	230	294
Taggart	68.6	2830	184	226	213	268
Illinois No. 6	66.8	1914	162	161	182	190

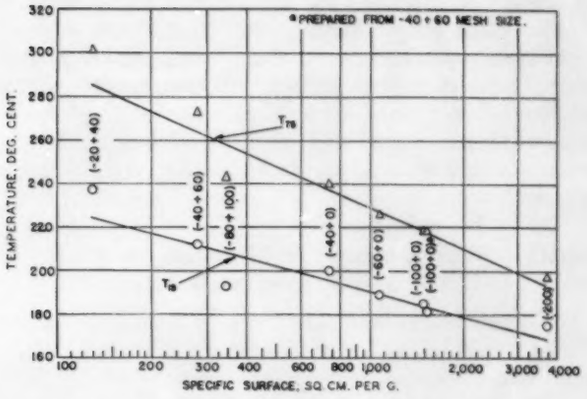

Fig. 11.—Relation of Surface Area to Ignition Temperature for Various Sizes of Elkhorn Coal.

The pressures required to force the standard rates of oxygen and air through the coal were as great as 15 in. of mercury. Mercury was substituted for water in the manometers on which the static pressures of the gases were determined.

Table V presents the results of ignition-temperature determinations on three coals both in 40–60 mesh size and as pulverized for boiler firing.

Because of their large specific surface, the pulverized samples had lower ignition temperatures than did the 40–60 mesh samples except for T_{15} for the Illinois coal. The differences for the two sizes were greater for T_{75} than for T_{15}. A complete explanation of the close agreement of the ignition temperatures of the two sizes of the Illinois coals is lacking. It was at least partly due to the fact that the pulverized coal had a relatively low specific surface. The small change in ignition temperature with change in size may be a common characteristic of coals of low ignition temperature, as it has already been shown that there was little difference between the ignition temperatures of 40–60 mesh and minus 60 mesh Indiana No. 6 coals which also had a low ignition temperature.

Relation of Ignition Temperature to Particle Size and Specific Surface

Data on the relation of the ignition temperature to the particle size and specific surface have been obtained on

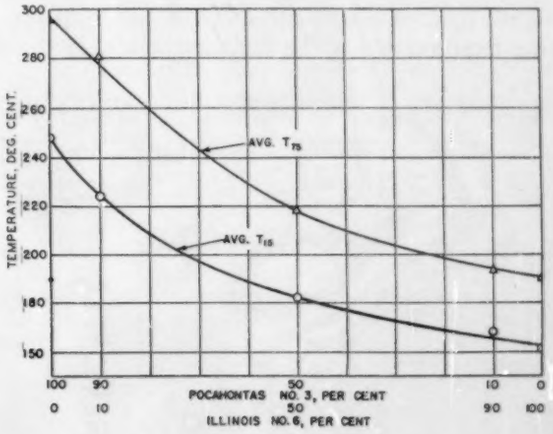

Fig. 12.—Ignition Temperatures for Mixtures of Pocahontas No. 3 and Illinois No. 6 Coals, 40–60 Mesh Size.

eight sizes of Elkhorn seam coal. Figure 11 presents the data with the temperatures plotted against the logarithm of the specific surface as determined by the air permeability method. Considering the fact that many of the samples are closely sized and thus do not represent all of the coal whereas others contain all of the coal below the given screen size, the data fit the straight-line relation remarkably well.

Ignition Temperatures of Mixtures of Pocahontas No. 3 and Illinois No. 6 Coals

The question has been raised as to the effect of the addition of a coal of low ignition temperature to one of high ignition temperature on the ignition temperature of the mixture. Data have been obtained on mixtures of 90, 50, and 10 per cent of Pocahontas No. 3 seam coal with 10, 50, and 90 per cent of Illinois No. 6 seam coal; 40–60 mesh coal was used. Figure 12 shows the results. It is seen that small additions of the Illinois No. 6 coal having the lower ignition temperature resulted in a reduction in the ignition temperature of the mixture more than proportional to the amount added. This is much to be expected, as the small amount of the highly reactive coal oxidizes independently of the less reactive coal.

Effect of Variation in Furnace Temperature at Start of Test on the Ignition Temperature

One criticism of this apparatus for the determination of the ignition temperature has been that, because of the mass of the copper furnace and its heavy insulation, about 8 hr. are required for the furnace to cool to room temperature. For this reason, the speed with which determinations can be made and, presumably, the value of the method are limited. To determine whether the results would be affected if the furnace were not allowed to cool entirely to room temperature, a series of deteminations was made using minus 60 mesh Harlan seam coal with the furnace temperature at starting time at 25, 100, 125, and 150 C. With each starting temperature, the furnace was heated higher than the desired temperature and was thus cooling when the test was started. The samples were placed in the reaction tubes when the desired temperature was reached, the rate of flow of gas was adjusted quickly, and the tests were started.

Table VI presents the results obtained. The agreement among the ignition temperatures determined with varying starting temperatures of the furnace is quite good. The maximum deviation from the average was 4 C. for T_{15} with a starting temperature of 150 C. These data show that it should be possible to start a test with the furnace temperature at about 50 C. below that at which crossing is expected to occur. This will require three to four hours for the furnace to cool and will permit two tests daily, which is about the maximum that one man can make and calculate.

TABLE VI.—EFFECT OF FURNACE TEMPERATURE AT STARTING ON IGNITION TEMPERATURE OF MINUS 60 MESH HARLAN SEAM COAL.

Test	Starting Furnace Temperature, deg. Cent.	Time for Furnace to Cool to Starting Temperature, hr.	Ignition Temperature, deg. Cent.	
			T_{15}	T_{75}
No. 263	25	8.+	185	210
No. 264			180	210
Avg.			*183*	*210*
No. 265	100	4.4	184	207
No. 266			183	212
Avg.			*184*	*210*
No. 271	125	3.2	184	213
No. 272			183	209
Avg.			*184*	*211*
No. 267	150	2.25	190	208
No. 268			187	209
No. 269			186	208
No. 270			183	212
Avg.			*187*	*209*

TABLE VII.—RESULTS OF IGNITION TESTS ON 40–60 MESH FUELS FROM VARIOUS LOCATIONS.

Seam	Location	Volatile, per cent Moisture and Ash Free	Avg. T_{15}, deg. Cent.	Avg. T_{75}, deg. Cent.
Bituminous				
Illinois No. 6	Christian, Ill.	44.9	161	190
Indiana No. 6	Sullivan, Ind.	42.8	172	202
Millers Creek	Johnson, Ky.	36.9	203	254
Elkhorn	Letcher, Ky.	35.6	213	263
Taggart	Wise, Va.	34.8	226	268
Pittsburgh	Fayette, Pa.	37.0	225	275
Powellton	Kanawha, W. Va.	35.3	228	275
C Prime	Somerset, Pa.	18.9	241	294
Pocah. No. 3	McDowell, W. Va.	17.4	248	296
Fulton	Huntington, Pa.	17.4	252	304
Pocah. No. 4	McDowell, W. Va.	17.4	252	308
Subbituminous				
Laramie	Weld, Col.	39.8	171	199
Lignite				
168 in. thick	Ward, N. D.	48.3	168	199
Charcoal		21.2	181	209
Anthracite				
Grassy Island	Lackawanna, Pa.	6.9	277	372
Buck Mountain	Schuylkill, Pa.	4.5	355	487
Coke				
(High temp. coke	from mixed coals)	1.0	463	532
Carbonite	Curran-Knowles Oven Illinois No. 6 Coal			
Top		5.0	363	433
Middle		2.3	456	499
Bottom		1.7	496	533
Entire sample		3.3	412	471
Disco	Wisner Process Pittsburgh Seam Coal	18.9	210	282

Probable Error of Method of Determination of Ignition Temperature of Coal

The probable error of this method of the determination of the ignition temperature of coal has been calculated from the data obtained both by the Peters' formula (*27*), and by the root mean square method. Excluding tests made on anthracite and coke, those made at furnace heating rates above 800 and below 500 w., those using other than air or oxygen, and those with rates of flow different from the standard rates, the average probable error for 86 tests was for T_{15} 2.1 C. and for T_{75} 1.9 C. or an average of 2 C. This accounts only for the error in the apparatus and operator and does not include the error of sampling or of different apparatus.

Too few determinations have been made on coke and anthracite for a determination of the probable error for these fuels, but it is undoubtedly greater because of the small angle at which the curves of sample and furnace temperature cross and the consequent greater error in the determination of the slope.

Ignition Temperatures of Various 40–60 Mesh Fuels

In the course of this investigation the ignition temperatures of a considerable number of coals and of a limited number of cokes have been determined. Table VII shows, for purposes of information, the results obtained on a number of these fuels in the 40–60 mesh size.

Conclusions

The data obtained in this investigation of the method of determination of the ignition temperature of solid fuels proposed by Sebastian and Mayers of the Coal Research Laboratory of Carnegie Institute of Technology show that it is well conceived to determine "the temperature at which the rate of oxidation attains some definite value under standard conditions" which has been defined as a useful criterion of the performance of fuel in combustion equipment.

The investigation has confirmed the facts that variations in the rate of supply of oxygen or of air, variations in the concentration of oxygen, variations in the rate of heating of the furnace, variations in packing or in the height of the sample, or variations in the temperature of the furnace at the start of the test within rather broad limits do not materially affect the results when expressed as T_{15} and T_{75}, which are the temperatures at which the temperature of the sample crosses that of the furnace when the rates of rise of the temperature of the sample are 15 and 75 C. per min., respectively.

The experiments have also shown that the method can be used on samples of fuel crushed to pass the No. 60 sieve which is the standard for many other determinations on solid fuels and that it can be extended to coal pulverized as for boiler or industrial furnace firing. Other than the inherent characteristics of the fuel, the particle size or specific surface is shown to have a large effect on the ignition temperature and for one Elkhorn seam coal the ignition temperature is shown to be inversely proportional to the logarithm of the specific surface of the sample.

The probable error on the determinations of the ignition temperatures of coal made during the course of the investigation has been calculated to be 2 C. Ignition temperatures of a number of coals and of a few cokes and anthracites are presented as a matter of information. Data for mixtures of two coals, one of high and one of low ignition temperature, show that additions of the coal of low ignition temperature decrease the ignition temperature of the mixture more than proportionately to the amount added.

After a method such as this is perfected to the point that consistent results can be obtained in the same and in different laboratories, it remains to be found whether the data obtained by its use have engineering meaning and value, that is, whether they show differences among coals that are directly reflected in the use of the coals. It would appear that results obtained on coals as pulverized for firing should be of immediate value to classify coals as to their relative ease of ignition and rate of combustion. As for coal to be burned in larger sizes on grates, no predictions are made as to the utility of the data obtained by the method. Further investigations on larger-scale apparatus are required to bridge the gap between the small-scale test and combustion on grates. An investigation of this type is now under way at Battelle.

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MR. M. A. MAYERS[1] (*presented in written form*).—The writer wishes to express his thanks to Messrs. Sherman, Pilcher, and Ostborg for their careful and complete verification of the method described in this paper. It is very gratifying to find that one's brain-child passes its tests.

The data given in the authors' Fig. 11, on the relation between T_{15} and T_{75} and the specific surface, afford another opportunity to check the ideas (1) that the method is essentially a measurement of the rate of a heterogeneous reaction, and (2) that the specific surface, measured by the method of Carman and Lea and Nurse (references *25* and *26* of the paper), is the relevant surface for this purpose.

If we let μ^* represent the rate of the heterogeneous reaction per unit partial pressure of oxygen per unit surface of the solid, p the oxygen partial pressure, s the specific surface of the solid, b the heat of reaction, c the specific heat of the solid, the fundamental equation on which the method is based may be written:

$$c\frac{dT}{dt} = c \tan a = \mu^* psb \ldots\ldots\ldots\ldots (1)$$

where tan a has the same meaning as in Eq. 1 of the paper. Hence,

$$\frac{b}{c}\mu^* = \frac{1}{ps}\tan a \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

The appearance of s in the denominator of the right-hand side of Eq. 2 is in accord with the principle in kinetics that the surface of solids is equivalent to the pressure of gases in representing concentrations of the reactants. Since μ^* is expected to obey the Arrhenius equation, we have, on taking logarithms

$$\text{Log}\frac{1}{p}\tan a - \log s = b^* - \frac{E}{4.575\,T} \ldots\ldots (3)$$

which is similar to Eq. 1 of the paper except for the appearance of the term in s.

Now, by definition, when $T = T_{15}$, $\log\frac{1}{p}\tan a = K_{15}$, a constant (and similarly for T_{75}). Solving Eq. 3 for log s, the values of T_{15} or T_{75} of samples of the same material ground to different degrees of fineness should be related by:

$$\log s = K_{15} - b^* + \frac{E}{4.575\,T_{15}}$$

or $\ldots\ldots\ldots\ldots (4)$

$$\log s = K_{75} - b^* + \frac{E}{4.575\,T_{75}}$$

Hence, if log s is plotted against $\frac{1}{T_{15}}$ or $\frac{1}{T_{75}}$, straight lines should result having the same values of the slope, $\frac{E}{4.575}$, as found from the comparison of samples of the same material tested in air and in oxygen.

The accompanying Fig. 1 shows how nearly the data of the authors' Fig. 11 follow this rule. The fit of the T_{75} points is quite satisfactory except for the one with specific surface of 350 sq. cm. per g. The slope of the line drawn through them corresponds to a value of E of 16,700 cal., the same as that calculated from the values of T_{15} and T_{75} given for Elkhorn coal in Table VII. The writer is unable to explain the departure of the T_{15} points from a single line, but they do appear to fall on two parallel lines of the same slope as that given by the T_{75} points.

MR. P. NICHOLLS[2] (*presented in written form*[3]).—The study of the proposed method for measuring the ignitibility of solid fuels is helpful in that it covers the general effects of variations in conditions of test. The authors show that repeatability apparently is very good and that, fortunately, values do not depend much on factors such as density of packing, which might be difficult to control closely.

On the other hand, some factors, such as size and heating rate, were found to have material effects, as would be expected from the fact that ignition is a process whether done on a large or small scale. It might be hoped that, although such variations would affect the *absolute* values as determined for different fuels, yet their *relative* values would have the same proportionality; however, the data indicate that this is not true.

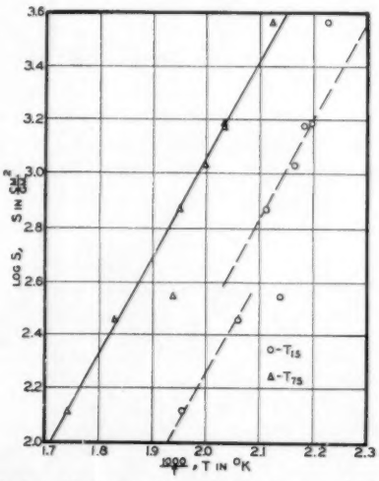

Fig. 1.—Relation Between Specific Surface and Reactivity for Elkhorn Coal.

Again, it might be hoped that the relationships between values and the variables would be consistent and simple. This does not hold for size, which is the most important variable; Fig. 11 shows that the ignition temperature of Elkhorn coal decreases materially with an increase in surface area, whereas Table IV implies that the ignition temperatures of the Pittsburgh and Pocohontas coals were independent of the surface areas for the ranges used.

This means that much experimentation will be required in an attempt to find the test conditions that should be imposed so that the results can be interpreted to give a scale of single values to which more or less definite meaning may be assigned.

Certainly it would be a simplification if a size range of

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[3] Published by permission of the Director, Bureau of Mines, U. S. Department of the Interior.

40–60 mesh could be used, but one would never feel satisfied with the results when some portion of the coal was eliminated. Tests with no low limit to size are evidently more difficult, but probably 0–60 or 0–40 mesh will have to be adopted.

Further experimentation on changes in details of the apparatus are worth while. Has there been experimentation to determine the relationship of the temperature of the gas entering the coal to the temperature of the copper? How far would this influence the effect of rate of flow? The use of the porous plug to hold down the small-size coal is questionable. Will not its resistance be so high that the gas stream will be diverted to flow round its edge? Gauze made of heat-resisting wire may be more satisfactory.

It would seem advantageous to be able to cool the furnace quickly, also to remove easily the glass tubes after each test for cleaning and refilling. We shall experiment with these and other details.

MR. RALPH A. SHERMAN.[4]—Mr. Nicholls has raised a point in regard to the effect of size of particle on the ignition temperature that should be clarified as it may puzzle others. He has pointed out that the data in Table IV show apparently little effect of change in particle size and specific surface whereas the data of Fig. 11 show rather large differences. It must be noted, however, that the data of Fig. 11 cover a wide range of specific surface, 150 to 3500 sq. cm. per g., whereas the variation for the samples prepared in different ways was from 1280 to 2260 for the Pittsburgh coal and 1480 to 3870 for the Pocahontas coal. Reference to this range in Fig. 11 shows that the maximum expected difference would be 10 to 15 deg. for T_{15} if the samples followed the straight line drawn through the points. It is noted, however, that the points for the minus 200 mesh coal did not fall on the curve and the spread even for the Elkhorn coal was not great in this range. For this reason, the conclusion given in the text in regard to the preparation of the samples in the minus 60 mesh size seems warranted.

Mr. Mayers' analysis of the relation of the ignition temperature and the specific surface is most interesting and the straight-line relation for T_{75} that he shows in the accompanying Fig. 1 seems justified, but a straight line of different slope might well be drawn through the points for T_{15} with as much assurance as the two straight lines. Further data will be required to establish this.

MR. W. A. SELVIG.[5]—How well can different laboratories check in duplicate determinations on the same coal?

MR. SHERMAN.—Mr. Selvig's question is very good. We have results only on samples that have been exchanged between Battelle and the Coal Research Laboratory:

Coal or Coke	Laboratory	Average T_{15}, deg. Cent.	Average T_{75}, deg. Cent.
High-temperature coke	CRL	466	523
	BMI	463	528
Elkhorn coal	CRL	207	251
	BMI	210	265
Edenborn coal	CRL	221	267
	BMI	222	274
Coal A	CRL	206	248
	BMI	211	264
Coal B	CRL	210	258
	BMI	210	270
Coal C	CRL	204	253
	BMI	213	264

You can see that for T_{15} the maximum difference is 9 C.; for T_{75}, they are similarly good. The differences are 5 deg., 14, 7, 16, 12, and 11. Mr. Rees told me that on one sample that we had sent him, the Edenborn coal on which so many determinations had been made, he likewise got very close checks with us. We are hoping that other laboratories will make an apparatus. Mr. Nicholls is building an apparatus at present, and very probably there will be others.

I want to emphasize particularly that we believe at the present time the method is quite suitable for use in connection with the combustion of pulverized coal, using coal as pulverized for any purpose. You can determine the ignition temperature, and although we do not know the order of significance of a few degrees difference in ignition temperatures, we are certain that the difference in ease of ignition will be of the same direction as shown by the difference in ignition temperatures.

The three coals on which the determinations were made in pulverized form, have been burned in connection with an investigation at Battelle in our experimental pulverized-coal furnace, and we have data to show that the burning characteristics are of the same order as their ignition temperatures.

MR. A. W. GAUGER.[6]—Figure 10 of the paper shows results on two different sizes of various seam samples—Indiana No. 6, Millers Creek, and so forth. As a matter of curiosity, I want to know just what these lines mean: does the minus 60 mesh line mean that the ignition temperature of Indiana 6 and Millers Creek, and Millers Creek and Pittsburgh follow that curve when mixed? The experiments illustrated in Fig. 12 for mixtures of Illinois No. 6 and Pocahontas No. 3 do not show such a straight-line relationship. In other words, I think these data should not be shown in the final publication in this form.

MR. J. M. PILCHER.[7]—The line was drawn in Fig. 10 merely to connect the points and to bring out clearly the difference in the spread of T_{15} and T_{75} for the two sizes of each coal. No relation between the ignition temperatures of the coals or of any mixtures of the coals should be assumed from this figure.

MR. R. B. TEXTOR.[8]—I should like to ask Mr. Sherman and his collaborators about what the expense of this apparatus is. If you are going to get a real amount of work done, the way to do it, of course, is to encourage others to work along the same line, and I am wondering whether there are any points in the technique that require special skill or familiarity with it, or whether it is a rather simple setup that a commercial laboratory could install without too much trouble and difficulty, and whether it could be done without having a graduate chemist to operate it. After all, we are just feeling our way at this time.

MR. SHERMAN.—Those who have built the apparatus have never listed the cost of various parts, but we estimate that seventy-five to one hundred dollars would pay for the material costs and machine work involved, including a

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[8] Sales Manager, The Textor Laboratories, Cleveland, Ohio.

variable transformer, which is the most expensive single piece of equipment. Of course, you have to have a potentiometer, but most laboratories have one and may also have the variable transformer.

This estimate, of course, does not cover the total cost of the apparatus, and does not include the time of the man to set it up. We do not know exactly what this has been, because there have been research projects in every laboratory in addition to this.

We do not believe that it would require a highly skilled graduate chemist to run the apparatus. It can be a rather routine matter. A man who is trained in careful observation in relation of time and temperature and other ordinary laboratory determinations, should be able to run the equipment very well.

MR. H. J. KERR.[9]—I should like to ask the authors whether they would make some mention of the possible effect of moisture in the sample.

[9] Executive Assistant, The Babcock & Wilcox Co., Barberton, Ohio.

MR. MAYERS.—I think I may be able to answer that question. We have run some coals with different moisture contents, and although we have not done it on a wide range of coals, or a wide range of moisture contents, it does not appear to have any particular effect. All the moisture, apparently, is driven off before you get to the point where you will observe T_{15} and T_{75}, so actually you are always working with dry coal when you get to the crossing point.

MR. H. N. OSTBORG.[10]—On a sample of Illinois No. 6 coal which we ran, we found that reducing the moisture content of the Illinois No. 6 by approximately 7 per cent had no appreciable effect upon the experimental ignition temperature. T_{15} for the undried sample was 162, as compared to T_{15} of 162 for the dried sample, and T_{75} for the undried sample was 182, as compared to 178 for the dried sample.

[10] Research Engineer, Fuels Division, Battelle Memorial Institute, Columbus, Ohio.

Brazilian Association for Technical Standards (A.B.N.T.) Organized

THROUGH THE COURTESY of Mr. Paul Sá, Secretary-Director, information has been received concerning the new Brazilian Association for Technical Standards (The Associação Brasileira de Normas Tecnicas—A.B.N.T.), which is a civil association organized under the patronage of the Brazilian Government but independent of government supervision, with the objectives of preparing and approving specifications for materials, codes for the execution of technical works and all technical standards necessary to the industry and the commerce of Brazil.

Its membership includes two classes: namely, the collective (official entities, technical schools, laboratories, and private enterprises) and the individual.

The A.B.N.T. is under the direction of a Board of Directors consisting of President, Vice-President and Treasurer; a Directing Council made up of 12 members (three representatives from the industries, the consumers, the laboratories and the individuals); and a Secretary-Director who has the control of the Permanent Secretariat of the A.B.N.T.

The Directing Council is elected by all members of the A.B.N.T., while the Board of Directors is elected by the Directing Council from among its own members. Mr. Ary Torres has been elected President, Col. Neiva de Lima, Vice-President, Mr. Mario Ludolf, Treasurer, and Mr. Sá, Secretary-Director. The Secretary-Director is chosen by the Council for a period of at least four years.

The following is a list of the members of the Directing Council who represented the groups indicated below when Mr. Sá's letter was received in June:

Laboratories.—Paulo Sá, National Institute of Technology; Adriano Marchini, Institute of Technology of S. Paulo; and Col. J. Neiva de Lima, Brazilian Army Laboratories.

Producers.—Mario Leao Ludolf, Industrial Federation of Rio de Janeiro; M. Marcondes Ferraz, Industrial Federation of S. Paulo; and A. Ortenblad, Textile Federation of Rio Grande do Sul.

Consumers.—Eudoro Berlinck, Federal Department of Purchase; Antonio Raposo, City Government, Rio de Janeiro; and Arthur Castilho, Brazilian Assn. of Railway Cos.

Individuals.—Ary Torres, Director, Brazilian Metallurgical Co.; João Carlos Vital, President, Brazilian Institute of Insurance; and Rafael Xavier, Director, Division of Materials, Federal Dept. of Civil Service.

The procedure to be followed for the adoption of standards is as follows:

1. When some official entity or some private member of the A.B.N.T. is interested in the preparation of a standard, it asks the Secretary-Director to present the subject to the Board of Directors.
2. The Board of Directors brings the subject to the study of the Permanent Committee which is concerned with the matter. The Committee is composed of representatives from the industry, the commerce, the official departments which have any interest in the subject, in order to strike a balance between the representation of consumers and producers.
3. The Committee chooses among its members a subcommittee which prepares a draft of the standard.
4. This draft is discussed by all the members of the Committee.
5. When the Committee agrees on a definite form for the specification, it is then presented to the Plenary Assembly of the A.B.N.T. at one of its annual meetings.
6. The Plenary Assembly adopts (or does not adopt) by a majority of two-thirds the standard proposed by the Committee.

All the standards proposed by the A.B.N.T. are accepted by the Federal Government and the governments of the Brazilian states.

Recently A.S.T.M. arranged to send to Mr. Sá's office copies of its proposed new specifications and tests so that any comments this group may have could be received and considered by the interested Society committees.

In connection with the standardization movement members will be interested to know that a new South American Committee on Standards is now in organization. Information about this group is being developed, which it is hoped can be published in the ASTM BULLETIN. The Brazilian members of this committee (termed COSAN) are Messrs. Torres, Sá, and Marchini.

Factors Influencing Creep and Cold Flow of Plastics*

By J. Delmonte[1] and W. Dewar[2]

INCREASING USE of plastics and resin-bonded plywoods for structural applications has created a demand for further information on creep properties of plastic materials. Test methods have been developed for measuring creep, using a 1/2-in. cube of the material placed under compressive stress for 24 hr. at 120 F.[2,3] While useful comparative results are obtained, a possible objection may be the thickness of the test specimen which may not be representative of the plastics as produced in sheet or molded form. In their applied form they are generally of thinner dimensions. Under a compression test of this nature, the relatively small amount of creep experienced for stiff, rigid materials increases the possibility of error.

For the tests described herein, creep measurements were conducted upon simple cantilever beam specimens. Determination of creep by beam deflection methods is also well known for metals.[4] Similar tests upon plastics were conducted earlier by one of the authors.[5] One advantage of beam deflection methods is the greater ease of observing creep, because the magnitude of the changes which occur is greater than in pure tension. Further, the physical properties of plastics are dependent upon the methods of manufacture, and hence it is desirable to use commercial grades and thicknesses as simple beams rather than thicker nonstandard pieces. While constant fiber stress is not developed on the specimens during test, the shear diagram for a simple cantilever beam with a constant weight at one end is quite uniform, and creep characteristics of both compression and tension are observed simultaneously under conditions approximating those in structural applications.

Specific aims of this investigation were as follows:

1. Determination of creep as a function of the time of application of the load at constant temperature and constant load, and recovery upon removal of the load.
2. Determination of the effect of temperature upon creep of representative samples of plastics.
3. Development of a short-time test to determine rapidly the magnitude of creep which may be expected in a plastic.

MATERIALS INVESTIGATED

The following materials were employed in conducting these tests:

1. Laminated phenolic, paper base, grade XX sheet (0.063 in. thick).
2. Polymethyl methacrylate, clear sheet (0.057 in. thick).
3. Cellulose nitrate, white standard (0.064 in. thick).
4. Cellulose acetate-butyrate sheet (0.063 in. thick).
5. Polyvinyl chloride-acetate sheet (0.057 in. thick).
6. Polystyrene, injection molded test bar (0.062 in. thick).

With the exception of the polystyrene, all samples used for tests were prepared accurately to 0.500 in. width with a test length of exactly 6 in., plus overhang for insertion in test equipment. The polystyrene test length measured 2.5 in. and a width of 0.250 in. Prior to test, samples were conditioned for 24 hr. at 50 C. and to maintain constant moisture content during the long tests, samples were lightly coated with paraffin wax after the conditioning treatment. Earlier tests by Penning and Meyer[3] showed the dependence of creep upon the moisture content of the samples. They reported an increase in the amount of creep with increased humidity used in conditioning the samples.

In addition to the above materials, samples of birch and poplar veneers were laminated together, and creep tests conducted upon these materials. These samples were not conditioned. Four-ply veneers were prepared. The direction of fibers was alternated in adjacent plies.

TEST METHOD

A schematic outline of the test equipment appears in Fig. 1. Specimens were cut to the size noted above, conditioned at 50 C. for 24 hr., and then mounted on the test block illustrated in Fig. 1. The test length of 6 in. was measured from the center line of the knife edge to the center line of the rounded eye, which was formed integrally with a suspension hook for weights. The weights were hung directly below the rounded eye contact member. On fastening specimens to the mounting block, it was felt that rather than rely upon a screw clamping plate, it was better to use an adjustable screw (pitch diameter, 1/2 in.)

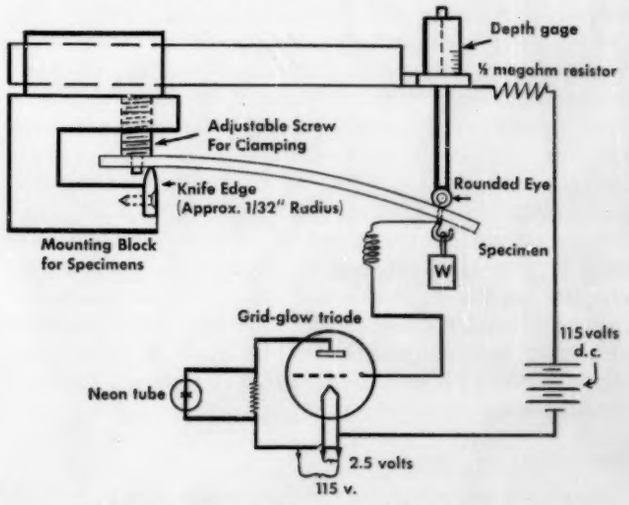


Fig. 1.—Schematic Diagram of Test Apparatus.

* Presented at the Forty-fourth Annual Meeting, Am. Soc. Testing Mats., Chicago, Ill., June 23–27, 1941.

[1] Technical Director, and Instructor, respectively, Plastics Industries Technical Inst., Los Angeles, Calif.

[2] Burns and Hopkins, *Modern Plastics*, Vol. 14, August, 1937, p. 42.

[3] Penning and Meyer, *Modern Plastics*, Vol. 17, November, 1939, p. 91.

[4] Joseph Marin and L. E. Zwissler, "Creep of Aluminum Subjected to Bending at Normal Temperatures," *Proceedings*, Am. Soc. Testing Mats., Vol. 40, p. 937 (1940).

[5] J. Delmonte, *Transactions*, Am. Soc. Mechanical Engrs., Vol. 62, August, 1940, p. 513; *Modern Plastics*, Vol. 17, May, 1940, p. 49, June, 1940, p. 65.

for clamping (see Fig. 1). In accomplishing this, the screw was finished flat across its end and left with a projection $^1/_8$ in. in diameter and $^3/_{16}$ in. long. The boss mated with a hole drilled directly in the test specimen. The screw was tightened down until the specimen was perfectly level. In this manner a control was exercised upon the degree of clamping. The center point of the adjustable screw was exactly on the center line of the knife-edge.

The mounting block was provided with 12 spaces for mounting specimens. The measurements were made with the aid of a depth gage reading to 0.001 in. and provided with a 3.5-in. stroke. This gage was movable upon a precision block forming part of the mounting block for specimens. It was possible to adjust the gage parallel as well as perpendicularly, with respect to the center line of the test specimens. Rather than rely upon visual observations for the establishment of contact of the depth gage upon the rounded eye, which was formed integrally with the suspension hook, the eye was connected electrically with a fine wire of negligible weight in the grid circuit of a grid-glow control tube (No. 885 gas-filled triode). At the completion of the contact, the grid assumed control of electron flow in the tube, and the neon light that was connected in the plate circuit went out. The gage was then slowly raised to that point just where the contact was broken, and the neon light appeared once again. The depth gage was then read with the aid of a magnifying glass. After a little practice, readings could be reproduced within ± 0.001 in.

In conducting these tests, particularly when thin specimens are used, every factor contributing to the weight at the end of the beam must be closely watched. For this reason, dial gages were not employed in measuring deflection because the weight of the spring mounted plunger was excessive.

Another modification of the above apparatus used in these tests is referred to in this paper as a spark test apparatus. Specimens were mounted in position with the aid of a clamping plate, and calculated weights were hung on the end to develop fiber stresses, as explained later. However, instead of relying upon a depth gage to make the deflection measurements, a spark was jumped from a point mounted upon the end of the specimen to a near-by chart mounted parallel to the plane of deflection of the beam. The big advantage of this method lay in the fact that deflection measurements after the weights were applied could be obtained almost instantaneously, without the delay usually attendant upon adjustment of the depth gage for a reading. Deflections were measured at the conclusion of the test with the aid of a pair of dividers. Deflection points were punctured on the graph paper by a high voltage supplied from an induction coil. When it was desired to make a reading, a contact was momentarily closed and a spark allowed to jump across the gap, puncturing a hole in the test paper. However, measurements with spark test equipment were not made with the same degree of precision as with the other equipment, having a reproducibility of only ± 0.005 in.

Developing Fiber Stress:

Weights were calculated for developing fiber stresses of 1000 psi. in most tests from the well-known formula

$$M = SI/c$$

where M = the maximum bending moment, equals weight × beam length,
S = the maximum fiber stress in pounds per square inch,
I = the moment of inertia, and
c = the distance from neutral axis to outermost fiber.

Thus, for example, in the above formula there would be substituted 1000 for S and values for I and c as determined by the physical constants of the test specimen, and the required weight would be calculated. In most tests, between 25 and 30 g. was the total weight at the end of the beam, including the rounded eye and hook for attachment of the weight. Corrections for the distributed weight of the test specimen itself would bring the total fiber stress up to 1050 to 1100 psi. In applying the above formula, the validity of Hooke's Law is assumed for the instantaneous deflection immediately following the application of the load. However, because of creep even at low stresses, deviations could be expected.

Measuring Deflection and Explanation of Terms:

Weights were carefully suspended on the hook at the end of the test specimen by hand, and the stop watch was started the instant the weight was applied. Sixty seconds were allowed to elapse before making the first reading of deflection with the depth gage. This time was ample to adjust the gage to position for making an accurate reading. This reading constitutes the initial deformation reading and is comprised of two parts: (1) elastic deformation, and (2) creep during the first 60 sec. In some cases the creep during the first 60 sec. was as high as 10 to 15 per cent of the instantaneous elastic deformation. Subsequent deflection at the end of the beam from 60 sec. to several hundred hours in some tests was measured and constitutes plastic deformation.

Plastic deformation exhibits two stages, one in which the rate of plastic deformation is continuously changing, and the other in which the rate of plastic deformation is substantially constant. Where the rate is changing, deformation phenomena are referred to as *creep* and where the rate is constant, deformation is referred to as *cold flow*. As an example, in Fig. 4 for polymethyl methacrylate at test temperatures of 20 to 85 F. after 25 hr. of applied load, deformation rate falls to a constant value which continues indefinitely. The deformation *after* 25 hr. for this resin would be referred to as cold flow, and before this time, as creep.

Measuring Recovery:

After the load was applied for the specified time, which is indicated upon all of the graphs, the recovery phenomena were observed for an equivalent period of time. Once again it was necessary to allow 60 sec. to elapse before adjustments could be made to take a reading with the depth gage. The initial recovery reading equals elastic recovery plus creep for 60 sec. Subsequent recovery at the end of the beam from 60 sec. on constitutes plastic recovery. The difference between the final point observed by the depth gage after recovery has about ceased, and the initial reading prior to the application of the weight constitutes

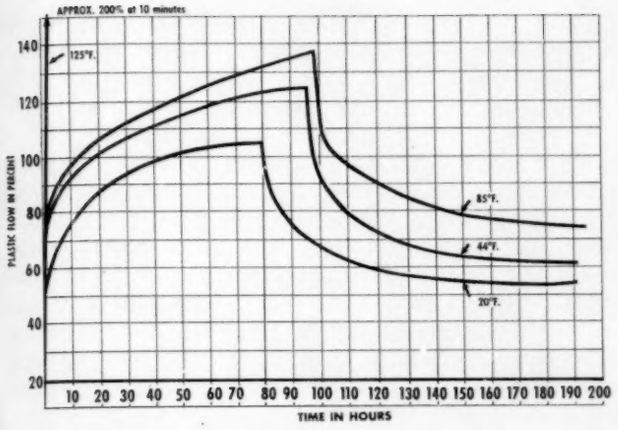


Fig. 2.—Time-Deformation Properties of Cellulose Acetate-Butyrate of 0.064-in. Thickness Subjected to a Maximum Fiber Stress of 1000 psi.

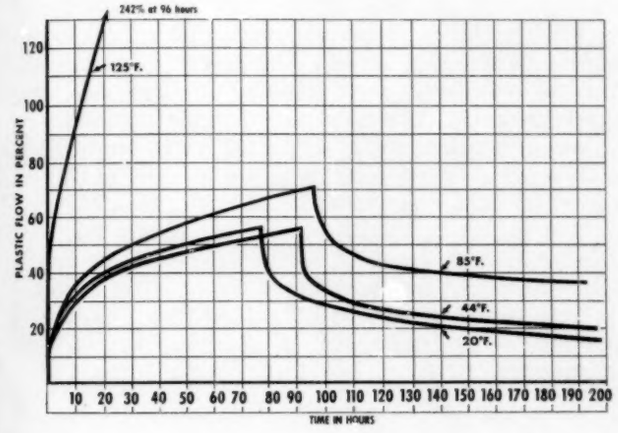


Fig. 3.—Time-Deformation Properties of Cellulose Nitrate of 0.063-in. Thickness Subjected to a Maximum Fiber Stress of 1000 psi.

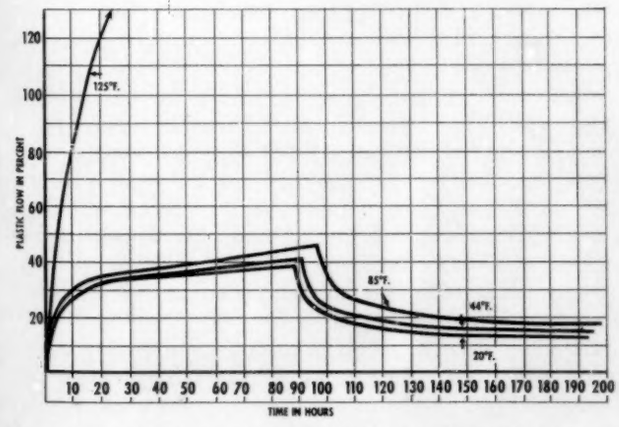


Fig. 4.—Time-Deformation Properties of Polymethyl Methacrylate of 0.056-in. Thickness Subjected to a Maximum Fiber Stress of 1000 psi.

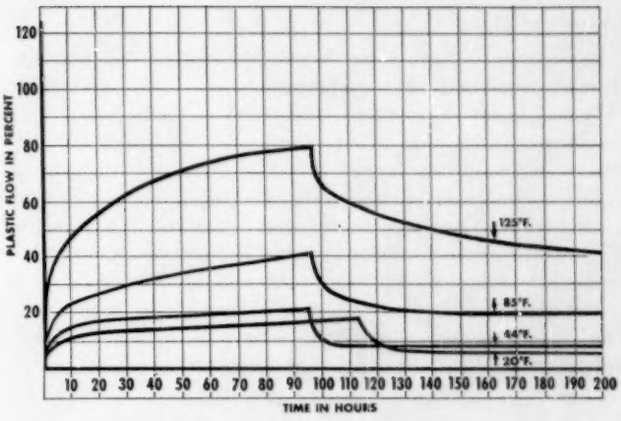


Fig. 5.—Time-Deformation Properties of Laminated Phenolic Grade XX, of 0.063-in. Thickness Subjected to a Maximum Fiber Stress of 1000 psi.

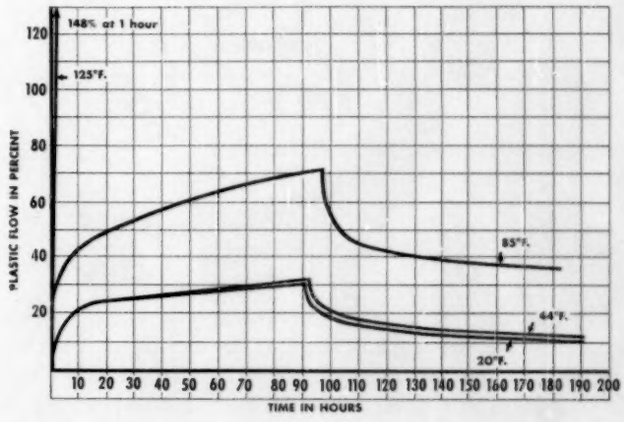


Fig. 6.—Time-Deformation Properties of Polyvinyl Chloride-Acetate of 0.057-in. Thickness Subjected to a Maximum Fiber Stress of 1000 psi.

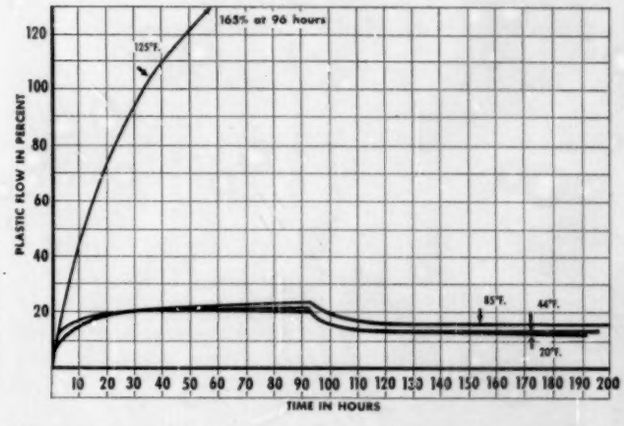


Fig. 7.—Time-Deformation Properties of Polystyrene of 0.063-in. Thickness Subjected to a Maximum Fiber Stress of 1000 psi.

permanent set. Thus permanent set = (elastic deformation + plastic deformation) − (elastic recovery + plastic recovery).

In all tests the deformation as measured at the end of 60 sec. was a few per cent higher than recovery measured over the same period. This ratio would be exactly unity if only true elastic deformation was involved. This was not the case inasmuch as plastic materials will exhibit creep even at very low values of stress. However, plastics exhibit true elastic behavior during instantaneous deflection under load and recovery from load. Measurements to determine these values are brought out later in this paper.

Plotting of Data:

In Figs. 2 to 7 are reported the time-deformation characteristics of cellulose acetate-butyrate, cellulose nitrate, polymethyl methacrylate, laminated phenolic, polyvinyl chloride-acetate, and polystyrene. The average time for which the load was applied was 96 hr., and the average time that recovery phenomena were observed was 96 hr. Recovery on some specimens was observed for a period about three times longer than that for which the load was applied, but further recovery was usually of the order of 1 to 2 per cent of that observed during the first 96 hr. The ordinates are plotted as plastic flow in per cent. This expression is obtained in the following manner:

For deflection while load is applied:

$$\text{Plastic flow (per cent)} = \frac{\text{Total plastic deformation after the 60-sec. reading + difference between initial deformation reading and initial recovery reading}}{\text{Initial recovery reading}} \times 100$$

For recovery after load is removed:

$$\text{Plastic flow (per cent)} = \frac{\text{Total plastic recovery after the 60-sec. reading}}{\text{Initial recovery reading}} \times 100$$

Because the initial recovery reading is smaller than the initial deformation reading, a correction is made in plastic flow readings while load is applied for creep occurring during the first 60 sec. by adding a term equal to the difference between initial deformation and initial recovery. By making this correction, the initial deformation is made exactly equal to initial recovery, the condition for true elastic behavior, and plastic deformation and plastic recovery are brought to a common base. Table I illustrates typical measured and calculated values.

TABLE I.—DEFORMATION DATA FOR POLYMETHYL METHACRYLATE SUBJECTED TO A FIBER STRESS OF 1000 PSI. AT 85 F.

Time	Reading of Depth Gage, in.	Plastic Deformation, in.	Plastic Deformation (Corrected), in.	Plastic Flow (Corrected), Percentage Recovery in 60 sec.
0	0.268	...	...	...
1 min.	1.314	1.046**	0	
30 min.	1.403	0.089	0.138[a]	13.8[a]
1 hr.	1.428	0.114	0.164	16.5
10 hr.	1.525	0.211	0.260	26.1
46 hr.	1.633	0.319	0.368	36.9
97 hr.	1.716	0.402	0.451	45.4

The load was removed at this time and measurements started immediately on recovery.

		Plastic Recovery, in.		
0	Unloaded			
1 min.	0.719	0.997*		...
30 min.	0.647	0.072		7.2
1 hr.	0.626	0.093		9.4
6 hr.	0.560	0.159		15.9
48 hr.	0.446	0.273		27.3
96 hr.	0.430	0.289		29.0

1.046**—60-sec. deformation. (Includes initial elastic deformation + 60-sec. creep.)

0.997* —60-sec. recovery. (Includes initial elastic recovery + 60-sec. creep.)

0.049 —Correction factor to be added to plastic deformation.

Permanent Set: 0.430 (final reading) − 0.268 (initial reading) = 0.162 in. or 17.0 per cent of elastic recovery.

[a] For example, 0.089 + 0.049 = 0.138 and 0.138 ÷ 0.997 = 13.8 per cent.

In plotting the data, to show the effect of creep and recovery more clearly, the initial deflection under load and the initial recovery are left off the curves and only those phenomena which are unquestionably due to plastic deformation and plastic recovery are included. The most significant facts about all of the curves is not so much the total measured deformation in inches but the proportion which the plastic deformation constitutes of the initial deformation under load, or, expressed in other words, the ratio of plastic flow to initial deformation, which deformation differs from true elastic deformation by the creep in the first 60 sec. The plotting of data in percentage allows comparisons to be made of beams of slightly different thicknesses, which was the case for the specimens used in these tests.

Temperature:

A few special remarks may be made concerning temperature adjustments in making measurements. Temperatures at which creep was observed were 20 F., 44 F., 85 F., and 125 F. The entire apparatus was placed in a constant temperature container at these respective temperatures, and after the specimens were mounted, enough time was allowed to permit the materials to adjust themselves to the operating temperature. While full data were obtained on all materials for deflections at 125 F., only small portions of the curves are shown in each case, because it was felt that the error beyond 120 per cent plastic flow was quite substantial, inasmuch as the effective beam length had substantially shortened due to the excessive deformation. However, data were obtained which would give some idea of the permanent set under loadings at these temperatures.

Inaccuracies in Measurements

Inasmuch as creep was to be determined as a function of temperature, fairly close control was maintained of the temperature. Four ranges were used during the test: (1) 20 to 22 F., (2) 44 to 46 F., (3) 84 to 86 F., and (4) 124 to 126 F. For higher temperature tests, special temperature-controlled boxes with air circulated by fans were employed.

Considerably greater accuracy could be expected in reading the 6-in. length specimens than the shorter polystyrene specimen, the order of the accuracy being a function of the square of their lengths. By taking a measurement, moving to a new position, and returning to make a new adjustment and reading, the greatest discrepancy in readings was of the order of 0.002 in. For total plastic flow in material such as laminated phenolic, this represents about 1.5 per cent reading error.

Specimens were cut accurately to size, and from measurements of physical dimensions, required loads were calculated and measured to the nearest 0.1 g. for each specimen. Inaccuracies due to weights and specimen sizes were less than 1 per cent. About the greatest source of inaccuracy occurred for specimens with greatest flow which deflected so much that the beam length was no longer 6 in.

While it is not possible to make readings by the spark test as accurately as with the depth gage, deflections were recorded with greater ease and more rapidly. The diameter of the pinhole in the paper formed by the spark, was adjusted to about 0.005 in. in diameter.

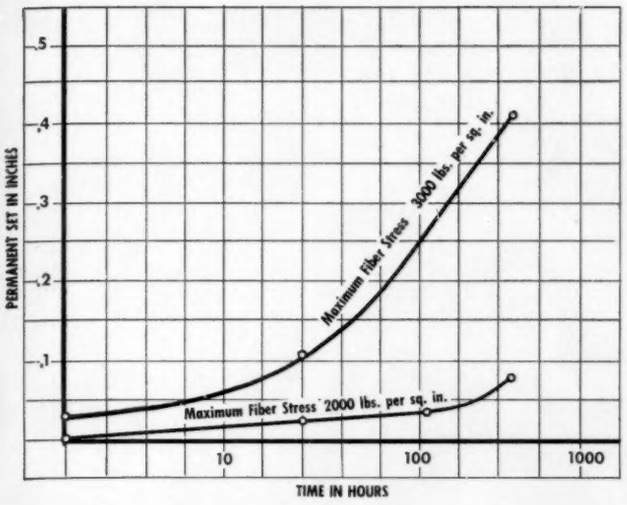


Fig. 8.—Effect of Time of Application of Load at 20 F. on Permanent Set of Grade XX Laminated Phenolic of 0.064 in. Thickness

Effect of Time of Application of Load:

To determine the effect of time of application of load upon permanent set, laminated phenolics were tested at 2000 and 3000 psi. maximum fiber stress. One set of weights was removed at the end of 1 hr., another set at the end of 24 hr., a third set at the end of 100 hr., and the last set at 330 hr. Before permanent set was determined, the specimens were allowed to remain unloaded for the same length of time as that during which they had been loaded. The last reading is taken as permanent set from original dimensions. The data obtained are shown in Fig. 8. The more rapid increase of permanent set at 3000 psi. is explained by the fact that at that stress the material is loaded beyond its elastic limit. Test data reveal that the plastics are capable of elastic deformation as well as

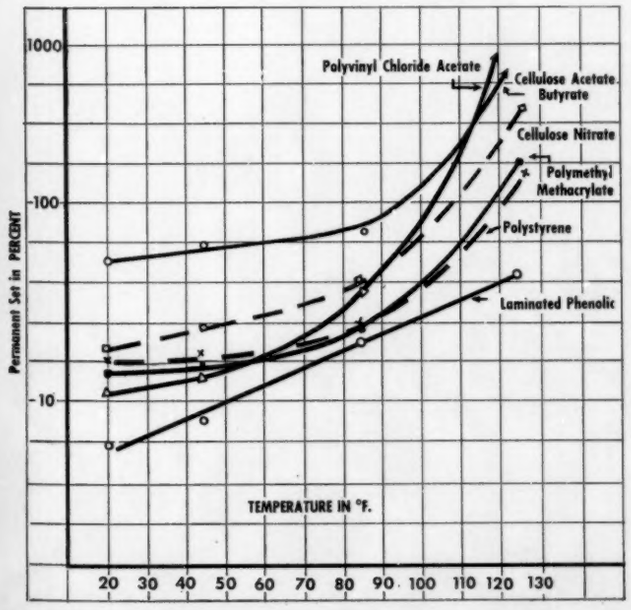


Fig. 9.—Permanent Set of Various Plastics as a Function of Temperature

Specimens were subjected to a maximum fiber stress of 1000 psi. for 4 days and allowed to recover for 4 days.

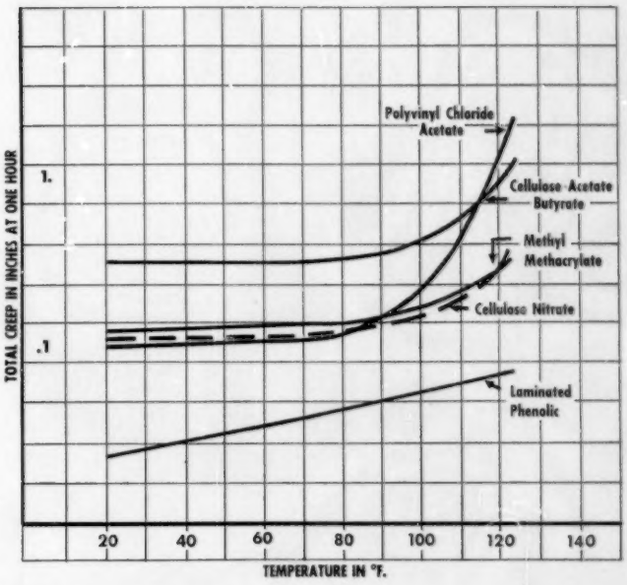


Fig. 10.—Creep of Various Plastics as a Function of Temperature when Subjected to a Maximum Fiber Stress of 1000 psi.

plastic deformation under stress. Consequently, it must be assumed that the structure of plastics is such as to embody an elastic portion as well as a portion capable of exhibiting plastic flow. When the elastic portion of the structure is overstressed, as it is at 3000 psi., plastic flow will be more pronounced than at lower stresses.

Effect of Temperature:

All the test data indicating permanent set as a function of temperature are combined in one curve, Fig. 9. Two materials, polyvinyl chloride-acetate and cellulose acetate-butyrate, deflected so much during the 96-hr. test under 1000-psi. maximum fiber stress at a temperature of 125 F., that the dead loads developing the stress rested on the bottom of the test box before the test was completed. The tendency to recover was observed only slightly in the case of the cellulose plastic. On the other hand, all other materials exhibited orderly deflection and recovery curves at this temperature. The 1-hr. total creep measurements for all samples tested are also shown as function of temperature in Fig. 10.

Modulus of Elasticity:

Modulus of elasticity is readily calculated from instantaneous deformation or instantaneous recovery phenomena, where true elastic phenomena are observed. The modulus of elasticity for simple cantilever beams is calculated from the well-known formula:

$$\text{Deflection} = WL^3/3EI$$

where E = the modulus of elasticity,
I = the moment of inertia,
L = the beam length, and
W = the dead weight on end.

In making the above calculations, elastic deformation was observed with the aid of the spark test apparatus within 5 sec. of applying load.[6] In Table II is listed the

[6] It is assumed that within this time limit, the deformations were wholly elastic, that is, the recovery would be equal to the deformation.

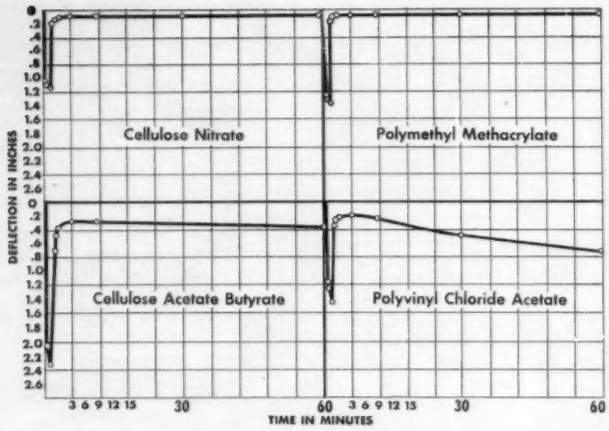


Fig. 11.—Typical Chart Recordings by Spark Apparatus of Deformation and Recovery of Plastics at 125 F.

modulus of elasticity of various plastics as calculated above. Some data are also given showing the change of modulus with temperature. Data are not given for cellulose plastics at 125 F. because the 1000-psi. test load exceeded the elastic limit, as evidenced by substantial differences between instantaneous deflection and recovery.

TABLE II.—MODULUS OF ELASTICITY OF PLASTICS DETERMINED BY ELASTIC DEFORMATION MEASUREMENTS WITH SPARK RECORDING APPARATUS.

Material[a]	Modulus of Elasticity, psi.	
	At 75 F.	At 125 F.
Polyvinyl chloride-acetate	480 000	356 000
Polymethyl methacrylate	442 000	322 000
Laminated urea	1 580 000	1 500 000
Laminated phenolic, grade XX	1 050 000	.....
Cellulose nitrate	406 000	.....
Cellulose acetate	318 000	.....
Cellulose acetate-butyrate	186 000	.....

[a] All specimens were conditioned by heating at 50 C. for 24 hr.

It is very significant that while the modulus of elasticity for many plastic materials decreases about 25 per cent in going from 75 F. to 125 F., the rate of creep and magnitude of permanent set increase about 1000 per cent, as shown in Figs. 9 and 10. Changes in physical properties have been noted in other tests[7] where tensile strength of polymethyl methacrylate decreased 50 per cent in changing from 54 F.

[7] Bartoe, *Mechanical Engineering*, Vol. 61, December, 1939, p. 892; *Modern Plastics*, Vol. 17, March, 1940, p. 47.

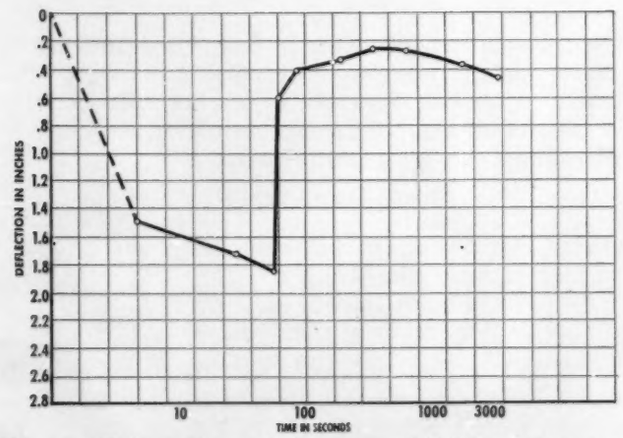


Fig. 12.—Deformation and Recovery of Cellulose Acetate of 0.075 in. Thickness Subjected to a Maximum Fiber Stress of 1000 psi. at 125 F.

to 122 F. This change, however, is small as compared with changes in the rate of creep.

Typical results as recorded on a constant speed chart appear as in Fig. 11. Reading from the zero mark, the first point recorded is the deformation after 5 sec., then 30 sec. and 60 sec. Recovery upon removal of the load after 1 min. was observed for 1 hr. Note how the specimens substantially recover from their deformation in 5 to 10 min., except for a certain amount of permanent set, and then begin to deflect again under their own weight (which creates a fiber stress of 50 to 100 psi.). For analysis purposes the results may be transcribed to semi-log paper, as was done for cellulose acetate in Fig. 12. Observe how, in this case, the instantaneous deformation under load (at 5 sec.) is substantially greater than the instantaneous recovery, in the ratio of 1.2 to 1. This indicates that a stress of 1000 psi. at 125 F. exceeds the elastic limit of cellulose acetate.

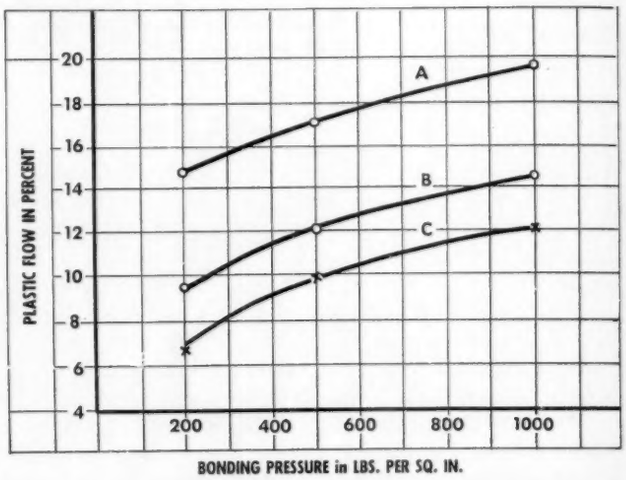


Fig. 13.—Creep Properties of Resin-Bonded Plywoods Subjected to a Maximum Fiber Stress of 2000 psi. for 15 min. at 125 F.

Average Modulus of Elasticity Birch—1,100,000 psi.
Average Modulus of Elasticity Poplar—1,000,000 psi.
4 ply (2 cross—2 length) of 1/24-in. Birch.
4 ply (2 cross—2 length) of 1/20-in. Poplar.
A—Birch bonded with 3 "Tego" films between plies.
B—Poplar bonded with 3 "Tego" films between plies.
C—Poplar bonded with 1 "Tego" film between plies.

Creep observed between 5 sec. and 60 sec. of loading is quite substantial for a number of plastics, particularly at 125 F. For example, the following table compares materials at 125 F.:

Materials Arranged in Decreasing Order of Permanent Set Observed in 96-hr. Test at 125 F. (See Fig. 9)	Creep from 5 sec. to 60 sec. at 125 F., per cent of Deformation at 5 sec.
Polyvinyl chloride-acetate	25.4
Cellulose acetate-butyrate	15.0
Cellulose nitrate	12.0
Polymethyl methacrylate	8.0
Polystyrene	..
Laminated phenolic	..

However, as will be recognized from Figs. 9 and 10, the order of the above materials with respect to creep phenomena change with temperature, and polyvinyl chloride-acetate which was the poorest at 125 F. becomes one of the best at 20 F.

A final set of tests is reported in Fig. 13 on resin-bonded

veneers. For the same time of cure at 300 F. and same bonding pressure, creep of a specimen bonded with a phenolic resin varnish was slightly higher than that of a specimen made with the phenolic resin film as bonding agent. The loads were applied for 15 min. and recovery noted for 15 min. Permanent set was small in all cases, of the order of 1 to 2 per cent of the deformation. Measurements were made on apparatus using the spark recorder. The effect of bonding pressure upon creep was clearly noted for birch and poplar veneers.

Conclusions

It is quite apparent from these tests that the often neglected creep and cold-flow phenomena become increasingly important for thermoplastic materials at temperatures above 80 F. As pointed out, the increase may be as much as 1000 per cent while changes in physical constants are very much smaller. These results may be readily recognizable from data appearing in Fig. 10. Until thermoplastics are developed which will creep much less at 120 F., their applications to structures are unlikely unless they are reinforced with some supporting metal member.

Cold flow, which is defined in this paper as that stage of plastic flow in which the rate of flow becomes substantially constant, was observed for several of the materials at temperatures below 85 F. However, a number of hours usually elapse before this state is reached. That creep will occur at even the lowest stresses is evidenced by plastic deformation of the beams under their own weight (stress 50 to 100 psi.) at 125 F. for thermoplastics.

Concerning the tests themselves, considerable time must be spent in making measurements in conducting the long-time creep tests, and for this reason it was felt that a test method which would give the desired comparative data in a few minutes would be desirable. It was with this purpose that the spark recorder was developed and representative data presented. The big advantage lies in the fact that deformation can be observed in a few seconds, and hence true elastic phenomena recorded. Even a wait of 60 sec. to make measurements at this temperature involves considerable plastic flow.

This would likewise be true for pure compression and tension tests on universal testers, which, in not being able to apply full load instantaneously, incur a substantial amount of creep before measurements can be made. It is felt for this reason that there is considerable merit in a short-time creep test by beam deformation methods, using a spark recorder for deflection measurements. A comparison of the plastics by this method was recorded in one of the tables.

A further advantage of the beam deformation test is the ease with which data are obtained to measure the modulus of elasticity. It is a well-known fact that such calculations are difficult to obtain from stress-strain curves of tests upon plastic materials. It is well known that modulus of elasticity in tension and compression is not the same for plastics, there being about 50 per cent difference in many cases. Consequently structural designers must make use of broad assumptions in applying the figures to their calculations. However, data obtained under conditions more comparable to the structural loads involving simultaneous tension and compression, would be more directly applicable.

The resin-bonded veneers behave very well as compared with plastics in creep and cold flow. However, the effect of greater bonding pressures may be noted in Fig. 13, which undoubtedly affect adversely the wood structure so that greater creep ensues. This would not necessarily be the case for fully resin-impregnated wood veneers where physical loads are carried by the synthetic resin structure rather than the cellulosic structure.

In conclusion, we wish to reiterate the importance and usefulness of the short-time creep tests as a means for making rapid comparisons of materials. It may be further concluded that thermoplastics in structural applications above 85 F. should be viewed with a great deal of caution, because while physical constants such as the modulus of elasticity and tensile strength do not change greatly, the creep values do.

DISCUSSION

Mr. H. F. Moore.[1]—Mr. Delmonte in his creep curves for plastics finds two stages which he calls the creep stage and the cold flow stage. These seem to correspond to the first two stages of creep which have been observed in metals—the stage of retarded creep rate and the stage of practically constant creep rate. In metals, if creep continues long enough, there appears a third stage—the stage of accelerated creep, necking down, and final fracture. It will be interesting to see whether plastics also develop this third stage.

Mr. W. A. Zinzow.[2]—The information relative to the creep characteristics of these materials which Mr. Delmonte has supplied is important in view of the fact that plastics are getting into the structural field. If the structural engineer is to use plastic materials, he must obviously need to know what the limitations are, and I know of no information that is more likely to bring out the limitations of plastics than these data.

The information would be much more useful, particularly if the range of the load which, as I understand it, was all in the region of 1000 psi., were not so close to the ultimate strength of many of the materials that were tested. In many cases where materials are to be used for structural purposes, loads in the region of 1000 psi. are not necessarily used, and many engineers need to know how the material is going to behave under a load of 10 or 100 psi. It may seem low, but actually, in many cases where tensile stability is required under load, the loads are quite low, and 1000 psi. is a bit too high.

We believe the time involved is a little short. A hundred hours, I believe, is the maximum that you use. If we had unlimited time at our disposal, we should like to run the tests for a period of 2000 or 3000 hr., because after all, if the creep is going to continue, we will get ultimate fracture.

Mr. S. J. Rosch.[3]—I wish to speak along the same lines

[1] Research Professor of Engineering Materials, University of Illinois, Urbana, Ill.

[2] Chief Chemist, Bakelite Corp., Bloomfield, N. J.

[3] Manager, Insulated Products Development, Anaconda Wire and Cable Co., Hastings-on-Hudson, N. Y.

as Mr. Zinzow. We did some work with wire insulated with polyvinyl chloride. We took about nine wires and placed them in a conduit. The wires were No. 14 A.w.g., each of which was insulated with 1/32-in. wall of the polyvinyl chloride.

The wires were installed in a 10-in. length of conduit, fairly tight, with a few feet of overlength extending beyond each end of the conduit. The overlengths were bent downward over the edge of the conduit, which had previously been reamed, and a weight was applied to the group of wires at each end so as to produce a stress on the resin as it rested against the edge of the conduit. The conduit edges were reamed out so as to make sure that the resin would not rest on any very sharp edges.

An assembly of this kind was placed in a panel and current passed through all of the wires in series so as to raise the temperature of the wires to 60 C. Similar setups were used with temperatures of 75 and 100 C., respectively. Each assembly was maintained at its temperature for a period of 30 days.

At one end, the group of wires was connected to an electrical circuit, the conduit itself forming the other part of the circuit, the idea being that if the resin wore through so as to permit the conductor to touch the conduit, contact would immediately be established and an indication given.

The surprising thing about the results of this test was that although these nine wires were maintained for a total of 720 hr. at 60, 75, and 100 C., respectively, nevertheless there was less deformation on the samples heated to 100 C. than those at 60 C.

It seems that if the surface of the resin is heated up very quickly, we get a form of oxide or hardening which absolutely changes the flexing characteristics of the material. The results that we obtained do not seem to check with the results you reported, although we also used polyvinyl chloride and at 100 C.

THE CHAIRMAN (*Mr. L. M. Currie*[4]).—I find that hard to explain. One question I would like to ask: Were the wires heated before the tension was applied to them?

MR. ROSCH.—No. The model was assembled and then placed in the panels and allowed to heat up very quickly by means of the current circulating through the conductors.

MESSRS. J. DELMONTE[5] AND W. DEWAR.[5]—Interest was expressed by both Mr. Moore and Mr. Zinzow on the creep of plastics at low stresses and creep after prolonged periods of time. Tests are now in progress to determine these effects, though the authors regret that they are not available at time of preparing this closure.

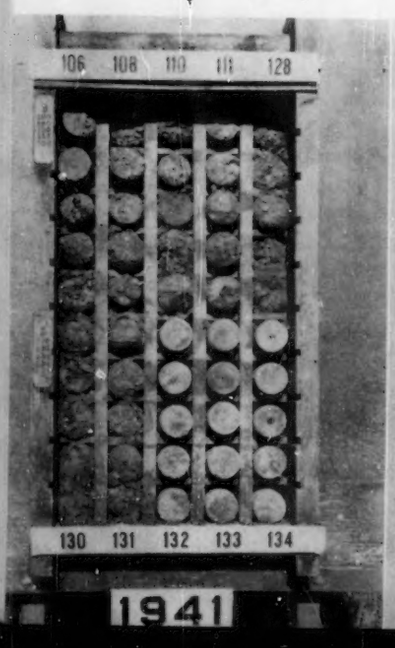
Concerning Mr. Rosch's comments of the behavior of polyvinyl chloride with increasing temperatures, it is obvious that there is another factor besides creep which influences his results, which are indicated by dielectric test. Our conclusion that creep will progress at an accelerating rate with high temperatures still stands, of course on the assumption that the chemical identity of the material is not altered by such temperatures.

[4] Director, Vinylite Division, National Carbon Co., Inc., Cleveland, Ohio.

[5] Technical Director, and Instructor, respectively, Plastics Industries Technical Inst., Los Angeles, Calif.

Photographs of Outdoor Performance Tests

IN ORDER TO DEVELOP authoritative data on the performance of various materials in service, the Society has conducted a large number of outdoor or other types of performance tests, many of these, of course, relating to the field of corrosion of metals and prevention of deterioration through the use of metal protective coatings or the use of paint and other preservative materials. Many tests are carried out in the nonmetallic field also, and an example of such an investigation is the project at Medicine Lake and University Farm at the University of Minnesota, involving durability tests of cements. The accompanying photographs used by Norman M. Stineman, Editor, *Concrete*, illustrate these tests. The particular investigations were described in a paper by Messrs. D. G. Miller and P. W. Manson entitled "Tests of 106 Commercial Cements for Sulfate Resistance," appearing in the 1940 A.S.T.M. *Proceedings*. The tests involve over 130 different brands of cement. This cooperative investigation was arranged under the sponsorship of A.S.T.M. Committee C-1 on Cement with a number of other organizations, Government departments, and industrial companies participating.



At left is one of the crates of 50 concrete test specimens taken from Medicine Lake for annual inspection. At right, a close-up of some specimens shows varying degrees of resistance to sulfate water. These specimens were made from various brands of cement.

Removing crates of concrete test specimens from Medicine Lake in preparation for recent annual inspection.

Photographs Courtesy *Concrete*

Emergency Alternate Federal Specifications

In line with the policy of announcing to the members the latest emergency alternate Federal specifications, as described in the August ASTM Bulletin with the latest list as of that date, there are given below the specification numbers and brief description of the emergency alternate Federal specifications received in the past few weeks.

As indicated, under this plan the Federal specification itself is not changed, but where they may be considered suitable alternates for the materials covered by the Federal specifications, emergency alternate requirements can become effective. Primarily, of course, they are issued in the interest of conservation of certain strategic materials.

In another article in this Bulletin relating to a large number of new specifications and tests approved by Committee E-10 on Standards, there is listed the first emergency alternate requirement in an A.S.T.M. specification.

ASTM Headquarters is prepared to distribute a limited number of the emergency alternate Federal specifications on request. Several members have taken advantage of this offer to obtain copies of those items in which they are particularly interested.

Specification Number	Description
E-OO-M-106	Machines, Vegetable-Peeling; Electrically Operated
E-QQ-B-666	Bronze, Aluminum; Bars, Plates, Rods, Shapes, Sheets, and Strips
E-QQ-B-671	Bronze, Aluminum; Castings
E-QQ-B-721a	Bronze, Manganese; Bars, Forgings, Plates, Rods, and Shapes
E-QQ-B-746	Bronze, Phosphor, Bars, Plates, Rods, Shapes, Sheets, and Strips
E-QQ-I-696	Iron and Steel; Sheet, Black and Zinc-Coated (Galvanized)
E-QQ-N-321	Nickel-Silver (German-Silver); Bars, Plates Rods, Shapes, Sheets, and Strips
E-QQ-T-201	Terne-Plate (Roofing Tin)
E-QQ-B-636	Brass, Naval; Bars, Plates, Rods, Shapes, Sheets, and Strips
E-QQ-T-191	Terne-Plate (Long Ternes)
E-QQ-I-706a	Iron and Steel; Sheet, Tinned (Tin-Plate)
E-QQ-B-611a	Brass; Commercial; Bars, Plates, Rods, Shapes, Sheets, and Strips
E-TT-A-466a	Aluminum-Pigment-Paste; (for) Paint
E-TT-A-476	Aluminum-Powder; (for) Paints (Aluminum-Bronze-Powder)
E-QQ-A-561	Aluminum, Plates and Sheets
E-QQ-A-411a	Aluminum; Bars, Rods, Shapes, and Wire
E-QQ-A-359	Aluminum Alloy (Aluminum-Manganese); Plates and Sheets
E-QQ-A-356a	Aluminum Alloy (Aluminum-Manganese); Bars, Rods, Shapes, and Wire
E-JJ-H-571	Hose; Fire, Linen, Unlined
E-FF-H-106	Hardware, Builders'; Locks and Lock-Trim (Tubular Locks) (Door Knobs and Roses)
E-QQ-S-571a	Solder; Tin-Lead
E-DDD-R-271	Ribbons; Computing and Recording-Machine
E-DDD-R-311a	Ribbons; Typewriter
E-HH-G-156	Gaskets, Rubber; Molded, Sheet, and Strip
E-HH-P-151a	Packing, Rubber; Cloth-Insertion
E-HH-P-161a	Packing; Rubber, Wire-Insertion
E-RR-C-85	Cans; Oil (Kerosene)
E-RR-C-94	Cans; Sprinkling
E-V-T-291a	Thread; Linen
E-UU-C-76	Cards; Guide (Card-Size)
E-UU-P-388a	Paper; Mimeograph
E-TT-V-71a	Varnish; Interior
E-TT-V-81a	Varnish; Mixing (for) Aluminum Paint
E-TT-V-121a	Varnish; Spar, Water-Resisting

Priority Rating Given Research Laboratories

Although many of the members undoubtedly have noted the announcements in the press of a special priority rating given to research laboratories, the gist of a statement from the Office of Production Management is given here. This rating in one sense recognizes the great importance of scientific research in the present National Defense program. The priority rating of A-2 was granted for equipment needed by research laboratories.

The Priorities Division has secured the assistance of the National Academy of Sciences in the operation of the new Research Laboratories Supplies Plan. The Academy will advise upon applications from laboratories for assistance under the plan.

A laboratory experiencing difficulty in securing essential materials, and wishing to qualify for the A-2 rating, should apply to the Chemical Branch, Office of Production Management, Washington, D. C., on Form PD-88.

The preference rating may be extended as far as necessary to assure ultimate delivery of scarce materials to the laboratory. A laboratory, when applying for the rating, should specify the number of copies of the order which will be necessary to enable its suppliers to serve them upon their own subsuppliers. No extensions of the rating to suppliers will be made directly by the Priorities Division. This must be done by the laboratory itself.

In the event that the laboratory finds itself unable to obtain some essential material with the A-2 rating, it should file an application with the Priorities Division on Form PD-1. If the research project is deemed of sufficient importance, the Priorities Division will issue an individual preference rating certificate, assigning a higher rating to a particular delivery of specified material.

All correspondence should be with the OPM Chemical Branch, and not with the National Academy of Sciences.

Government Paint Specifications Listed

Recently received from the Scientific Section of the National Paint, Varnish and Lacquer Association in Washington, D. C., is a revision of its Circular No. 618 prepared by G. G. Sward for the convenience of association members in locating sources and titles of Government paint specifications. Also included is a complete list of A.S.T.M. specifications pertaining to the field of paint, varnish, lacquer, and related materials.

Brief abstracts of Federal specifications are given. The circular (now designated Circular No. 627) covers not only Federal specifications but those used by many other Government divisions such as the Ordnance Department, the Navy, U. S. Coast Guard, Home Owners Loan Corp., Federal Housing Administration, and others.

Dr. H. A. Gardner, who is very active in A.S.T.M. work, is Director of the Association's Scientific Section.

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PHILADELPHIA, PENNA.

Committees' Statistics

BECAUSE OF INTENSIVE activity along so many really essential lines, there has been neither the personnel or time available for the Society to develop many statistics which might be most interesting. However the latest Year Book carries, as have previous editions, certain information that is worthy of comment. As mentioned in this BULLETIN some 100 pages of the Year Book are necessary to list the A.S.T.M. membership, but to give the complete personnel of the Society's committees over 150 pages are required which in itself indicates the importance of these groups in the Society's work.

There are 61 so-called standing committees, eight each in the field of ferrous and non-ferrous metals; 14 in the cementitious, concrete, and masonry fields; 17 in the "D" groups, paint, petroleum, coal, plastics, etc.; with eleven on miscellaneous subjects, mostly the "E" committees; and four are formal standing research committees, a total of 61. The total membership of these committees is 3682; thus the average committee size is 60 members. But the standing committees vary in size from D-13 on Textile Materials which this year has taken the lead from Committee A-1 on Steel with respective memberships of 240 and 230, to committees with less than ten members, the latter being primarily administrative groups. The subcommittees may vary from 50 to 60 members, depending upon how standing committees subdivide their activities into sections and smaller groups, down to working subcommittees of five or six members and a few cases to three or four. Eliminating duplication, that is, members of more than one committee and representatives of other societies, there is a net committee membership of 1870, of which almost 1100 are individuals, some 660 are companies, while Government departments, universities, etc., make up the balance of 150.

In addition to the standing committees with their several hundred subcommittees and sections, the Society has representatives on joint committees with other bodies and is actively concerned with numerous sectional committees functioning under A.S.A. procedure. So that all told the number of members serving on technical committees is roughly 2000.

With 2000 out of about 4500 members serving on technical committees (the great majority of these committees recognizing lack of activity by polite requests for resignations)—well, this in itself pretty well answers questions on how A.S.T.M. through its technical committees really gets so much accomplished in the field of standardization and research.

Research Article

FOR A NUMBER of years the October ASTM BULLETIN has presented a review of A.S.T.M. research projects, falling into two broad classifications: properties of materials, and methods of testing—but this year because of pressure of several matters at Headquarters it is not possible to include this research article in this issue, but it will appear in the December BULLETIN. Committee E-9 on Research feels that a listing, with condensed synopses of latest developments, provides an interesting summary which is of value in many ways and gives members some highlights of this phase of A.S.T.M. work.

Card File Lists Projects Related to National Defense

IN ORDER THAT THERE would be readily available concise information and references on research and standardization projects dealing with materials which are of direct or indirect importance in National Defense work, there has recently been set up a system of cards giving for a large number of standing committees notes on projects which would fall in this general category. Some 150 projects are covered with reference to latest committee reports, minutes of meetings or other sources giving the latest information. It is planned that these cards will be kept up to date and thus provide in convenient form information that is pertinent in connection with the respective committee projects. These cards include references to the several items listed in the August BULLETIN (page 15) as being of direct importance in National Defense, and many others.

Off the Line

THIS IS THE TIME of year when various publications—technical books, compilations of standards—roll off the "assembly line" and while these publications are rather prosaic, to be sure, if examined strictly for the physical elements they represent, paper, cloth, and ink, plus a little thread and glue, can they not with some imagination be thought of as a style of cornucopia which instead of pouring out an abundant store of fruits and flowers may very well help in making available the basic materials for a bridge, a boiler, a piece of soap, or a quart of oil . . . ad infinitum.

The ultimate representation of A.S.T.M. work is some finished structure in which a designer, fabricator, or workman has shaped and fitted into its proper place a product, the quality of which may very well have been determined and controlled by an A.S.T.M. test method or specification.

No doubt many committee members and officers heave a sigh of relief at seeing the publications become available, indicating that after hours and weeks and frequently months of effort, at last the job (or the first phase of it) is completed.

Actions on 1941 Standards Letter Ballot

A CANVASS on September 2 of the 1941 letter ballot on recommendations affecting A.S.T.M. standards showed that all items listed on the ballot were adopted. The ballot covered the adoption of revisions in 82 standards and the adoption as standard of 60 previously issued tentative specifications, methods, and definitions.

The canvass of the ballot showed that over 560 votes had been cast and while the itemized returns will not be published, any member of the Society who desires to know the vote on any particular item can obtain the information from A.S.T.M. Headquarters.

All of the revised standards, as well as all new tentative specifications and tests accepted at the annual meeting and the recent meeting of Committee E-10 (described in this BULLETIN) will appear in the 1941 Supplements to the Book of Standards, the Supplements to be issued early in November. An article referring to the Book of Standards Supplements appears elsewhere in this BULLETIN.

Offers of Papers for 1942 Meeting

COMMITTEE E-6 on Papers and Publications in anticipation of developing the program for the 1942 Annual Meeting at The Chalfonte-Haddon Hall, Atlantic City, June 22 to 26, is desirous that members of the Society and others who have in mind submitting offers of technical papers should send these offers to Society Headquarters well in advance of the February meeting of the committee. All offers must be accompanied by a summary which should make clear the intended scope of the paper and indicate features that in the opinion of the author will justify its inclusion in the annual meeting program. Suitable blanks to be used in transmitting the necessary information will be sent promptly on request.

1941 Supplements to Book of Standards Being Published; Distribution Early in November

INTENSIVE WORK on the new and revised specifications and tests which are to be published in the 1941 Supplements to the Book of A.S.T.M. Standards is under way and the Supplements to be issued in three parts—I on Metals, II on Nonmetallic Materials—Constructional, and III on Nonmetallic Materials—General, will be distributed to the members early in November. Each member receives the Supplements according to the respective parts of the Book of Standards he obtains.

Preliminary estimates indicate that Part I will have about 126 standards covering some 550 pages; Part II, 125 standards, 475 pages; Part III, 119 standards, 600 pages. These books will be bound in cloth conforming to the binding of the Book of Standards and will also be available in half leather for those who wish to procure this type of binding.

These books as their name indicates *supplement*, or bring up to date, both the 1939 Book of Standards and 1940 Supplements, since some of the standards in the 1940 Supplements have been changed this year. All specifications and tests adopted as standard are included; also revised standards and tentative standards, and each book includes in a special section the tentative revisions relating to the respective standards.

Each member of the Society receives one part of the Book of Standards with its Supplements, and the other two parts with Supplements can be obtained by paying an additional charge over the annual dues of $1.50 for two parts and $2.50 for all three parts. Many of the members get a complete set of the books. Extra copies of all the books can be purchased, the Book of Standards costing $8 per part, $15 for any two parts, and $22 for all three parts, and the Supplements costing $3, $5, and $7. The respective membership prices for extra copies are $5.50, $10.00, $14.50, and for Supplements $2.00, $3.50, $5.00.

Every member should be sure that he obtains a copy of the Supplements to the particular parts of the Book of Standards he may have. Stickers are furnished with the Supplement for affixing to the previously issued volumes any reference to later specifications or tests.

The Index to Standards which is now nearing completion will be sent to each member and will give him the latest references to all of the publications where the standards and tentative standards appear. This Index takes the place of a separate index in each of the Supplements.

New Designations for Copper Casting Specifications

THE AUGUST ASTM BULLETIN on p. 51 carried a list of new and revised tentative standards approved at the annual meeting, listing the complete titles and the new serial designations assigned. Of those listed seven covered specifications for copper and copper alloy sand castings. Subsequently, it developed that some changes should be made in the serial designations assigned to this particular group. The latest serial designations with their titles are enumerated below:

B 143 – 41 T—Tin-Bronze and Leaded Tin-Bronze Sand Castings
B 144 – 41 T—High-Leaded Tin Bronze Sand Castings
B 145 – 41 T—Leaded Red Brass and Leaded Semi Red Brass Sand Castings
B 146 – 41 T—Leaded Yellow Brass Sand Castings for General Purposes
B 147 – 41 T—High-Strength Yellow Brass and High-Strength Leaded Yellow Brass Sand Castings
B 148 – 41 T—Aluminum-Bronze Sand Castings
B 149 – 41 T—Leaded Nickel-Brass (Leaded Nickel-Silver) and Leaded Nickel-Bronze (Nickel-Silver) Sand Castings

Schedule of A.S.T.M. Meetings

DATE	COMMITTEE	PLACE
October 15–17	D-13 on Textile Materials	New York, N. Y.
October 19	D-3 on Gaseous Fuels	Atlantic City, N. J.
October 20, 21	C-1 on Cement	Allentown, Pa.
November 6, 7	B-5 on Copper and Copper Alloys	Washington, D. C.
March 2–6	SPRING MEETING AND COMMITTEE WEEK	Cleveland, Ohio
June 22–26	FORTY-FIFTH ANNUAL MEETING	Atlantic City, N. J.

Metal Congress in Philadelphia, October 20–24

THERE WILL BE HARDLY any phase of activity during the Metal Congress being held in Philadelphia, October 20–24, that is not of interest to some specific group of A.S.T.M. members, particularly, of course, in the field of ferrous and non-ferrous metals. In addition to the National Metal Exposition, which promises to be the largest yet held, an extensive series of technical sessions has been planned by the American Society for Metals and other participating societies including the American Welding Society, Wire Association, and the Institute of Metals and Iron and Steel Divisions, A.I.M.E. A large number of individuals active in A.S.T.M. work are on the technical programs and some of those in the Philadelphia area are serving on the local convention committee. A detailed program of the congress is being sent to A.S.T.M. members in the Philadelphia district through the courtesy of A.S.M.

Perhaps of particular interest will be the National Defense Group Meetings on Defense Problems, Conservation and Substitution at Convention Hall on the afternoon and evenings of the week. Authorities in industry, from service branches of the Government, and consultants will cover specific topics. At the close of discussion a summarizer will cover the high spots. C. L. Warwick, A.S.T.M. Secretary-Treasurer, is participating in two of these sessions, the one on copper and its alloys at which he will discuss standardization of specifications, and he will cover the same subject in a session on higher alloy steels. The program for these sessions is as follows:

Monday, Oct. 20, 2:30 p.m.—Low Carbon Alloy Steels (Case Hardening Steels); 8:00 p.m.—Manufacture of Shells; 8:00 p.m.—Aluminum and Magnesium in Defense.

Tuesday, Oct. 21, 2:30 p.m.—Higher Alloy Steels (Oil Quenching Steels); 2:30 p.m.—Copper and Its Alloys, originally scheduled for eight o'clock; 8:00 p.m.—Stainless and Heat Resisting Steel.

Wednesday, Oct. 22, 2:30 p.m.—High Strength, Low Alloy Steels (Weldable Grades for Pressure Vessels, Piping, Ships, Rolling Stock); 8:00 p.m—Inspection of Metals.

Thursday, Oct. 23, 2:30 p.m.—Alloy Castings (Steel and Iron); 2:30 p.m.—Bearing Metals.

Friday, Oct. 24, 2:30 p.m.—Molybdenum High Speed Steels and Tool Steels.

The morning sessions of the A.S.M. are being held at the Benjamin Franklin Hotel, convention headquarters, the afternoon and evening sessions at Convention Hall, where the Metal Exposition will be in progress.

Headquarters of the Welding Society are at the Bellevue-Stratford where its technical sessions are scheduled. Practically all of the topics at these sessions are of widespread interest to A.S.T.M. members including one on Monday morning at 10:15 covering weldability of plain carbon and low alloy steels, a structural session on Tuesday afternoon, and a research session on non-ferrous metals is scheduled for Monday afternoon running simultaneously with a shipbuilding session. There is a fundamental research session on testing methods Tuesday afternoon and on metallurgical problems on Wednesday afternoon.

Philadelphia District to Have Student Night Stressing Importance in National Emergency of Testing and Materials Engineers

EARLY IN DECEMBER (probably Friday, December 5), the A.S.T.M. Philadelphia District Committee will be host at a meeting designed to be of interest to engineering students and the faculty members in the numerous engineering schools in the Philadelphia area. Featured will be several short addresses by leading materials and testing engineers in the Philadelphia District covering topics that are of importance in connection with the present national emergency.

The meeting is planned for the Franklin Institute but full details will be given to all the some 500 Philadelphia District members who are urged to note this date on their calendars.

The committee in planning a meeting to emphasize the extreme importance of control and testing in National Defense felt that both the student engineers, faculty members and the Society members, having much in common, would benefit. Following the short meeting session refreshments are to be served.

The committee under the Chairmanship of F. G. Tatnall, Baldwin-Southwark Corp., with R. W. Orr, *Secretary*, RCA Manufacturing Co., Inc., has approved a continuation of existing subcommittees to carry on details of district work. J. W. Harsch, Leeds and Northrop Co., heads the Program Committee, E. J. Albert, Thwing-Albert Instrument Co., the Finance and Dinner Committee, J. F. Vogdes, Day and Zimmerman, Inc., the Publicity and Promotion Committee, and A. O. Schaefer, The Midvale Co., Notices and Literature.

Active Work on Electrical Insulating Materials

AT ITS TWO-DAY SERIES of meetings held in New York City at the Hotel Pennsylvania, on September 29–30, Committee D-9 on Electrical Insulating Materials discussed many projects and advanced several items for committee action.

Subcommittee I on Insulating Varnishes, Paints, and Lacquers considered conditioning of shellac for flow tests. There was a very extended discussion of the internal drying of varnishes. No definite proposals were advanced but from the discussion it is recognized that a real problem is involved and work will be undertaken as proposals are developed.

Subcommittee II on Molded Insulating Materials reported that the drawings for the standard molds are now available and have been sent to A.S.T.M. Headquarters. (Blueprints are available at nominal charge.) The members discussed work on the electrical properties of molded material and are preparing to develop a specification on phenolic molded material.

Subcommittee III on Plates, Tubes, and Rods has completed its work and submitted a method of measuring power factor parallel to the laminations of sheet insulation.

This will be submitted for letter ballot. Considerable time was devoted to a discussion of consolidating a number of committee sections dealing with different types of tests and materials into sections which will devote their efforts to mechanical tests and electrical tests of sheets, tubes, and rods. A report was made on a method of power factor measurement parallel to the laminations of rods and tubes. The specification for phenolic sheet insulation is being reviewed in order to change the permissible thickness variations.

Several sections of Subcommittee IV on Liquid Insulation met in advance of the meeting of the main committee. The section on dielectric strength reported minor changes recommended for that method and also is preparing a letter ballot on a method of dielectric test for synthetic liquid insulation. Test work on the influence of electrode shapes and rate of rise of voltage was also reported. The section on sludge tests discussed the results of the latest round robin and are preparing for further check tests. Their report, however, indicates that two methods, a short-time bomb test and a long-time referee test, will probably be ready for letter ballot by the next meeting. A lengthy meeting was held to discuss methods of determining moisture in insulating oil. A program has been mapped out in which a number of methods will be studied in about ten laboratories. These methods had been previously reviewed by the committee and seemed worthy of trial in a round-robin program. The other sections reported progress on gas determination of insulating oil and significance of tests on insulating oils. The sections on saponification tests and neutralization tests both reported that they are cooperating with Committee D-2 in work on insulating oils.

Subcommittee V on Ceramic Products (Porcelain, Glass, etc.) proposes to adopt a dye penetration test as covered in the A.I.E.E. standards and will modify mechanical tests of glass insulators so that both standards are in agreement. A report on the electrical properties of glass will be available for publication shortly. It is also proposed to recommend that the A.I.E.E. standards include provisions for tests of lime glass insulators which are not covered at the present time.

There was an extended discussion in Subcommittee VII on Electrical Tests covering methods of measuring resistivity of insulating materials, with particular attention to the time at which readings are taken. A new method for thermal conductivity was brought to the attention of the committee and will be studied. It offers prospect of speed and accuracy and requires only a small specimen. In Subcommittee VIII on Insulating Papers and Fabrics the round-robin tests on varnished fabric have been completed. This series covered the relationship between elongation, dielectric strength, and field application. Also being considered is a moisture test for this type of insulation. A report was made on the breaking strength of glass tapes. As a result of the work in Subcommittee IX on Mica Products, a method for measuring power factor of mica insulation will be submitted for letter ballot.

Subcommittee X on Conditioning is preparing to contact the Army and Navy authorities with a view to coordinating the conditioning methods and requirements in the specifications of A.S.T.M. and the Government bodies.

These series of D-9 meetings were directed by the chairman, Dr. T. Smith Taylor, Professor in Charge of Research and Graduate Studies, Newark College of Engineering, and the secretary, E. J. Rutan, Test Engineer, Consolidated Edison Co. of New York.

Committee C-8 on Refractories Meets

Two items of particular interest on which there was discussion and action at the meeting of Committee C-8 on Refractories held on September 4 in Grandville, Ohio, just before the summer meeting of the Refractories Division of the American Ceramic Society, involved specification requirements for plastic refractories and a decision to "standardize" on the use of Fahrenheit scale of temperature, the only exception being in the methods for chemical analysis.

The proposed specifications for fireclay plastic refractories cover material for boiler furnaces and incinerator service. This is the first time that Committee C-8 has made recommendations on material in this field—that is, covering material sold to the customer in a workable or plastic condition which can be rammed into place on the job, and which, in addition to being used as furnace linings, is used extensively as repair material. The proposed specification is being referred to letter ballot of Committee C-8.

Decision to adopt the Fahrenheit scale came about as the result of discussion by the editorial committee in its preparation of the 1940 Refractories Manual. Because the Fahrenheit temperature scale is almost universally used, it was felt wise to adopt this policy.

Other matters discussed at the meeting included the work on industrial surveys, nine of which have been published in the manual. Another is in preparation dealing with the use of refractories in the making of electric furnace steel and one covering the oil industry is nearing completion. The committee plans to develop still another survey covering refractories used in carbureted water gas equipment.

In order to amplify some of the requirements in existing standards, a recommended practice for the panel spalling test is being prepared which will give supplementary information on the construction, maintenance, and conduct of the test.

There was discussion at the meeting of research work being carried out on comparing certain characteristics and behavior of an electric and a gas-fired P.C.E. furnace. This comparative work, now under way at different laboratories, will afford valuable information to the committee. Other problems being studied by the committee, or work which is being closely followed by it involve tests and equipment for evaluating consistency of cold-set refractory mortars and investigations of heat transfer using types of Globar equipment.

The subcommittee in charge of specifications has developed a draft of requirements covering cold-set mortars of the wet type, and copies have been distributed for study and comment.

The C-8 meetings were arranged by the chairman of the committee, J. D. Sullivan, Battelle Memorial Institute, with the secretary, S. M. Phelps, Mellon Institute of Industrial Research.

Important Publications Issued Including Several Committee-Sponsored Standards Compilations

In addition to the 1941 Year Book and the List of Standards, brief descriptions of which appear in separate articles in this Bulletin, a number of other technical publications have come off press, including special compilations of standards sponsored by the respective standing committees in the fields of petroleum products and lubricants, cement, electrical heating and resistance alloys, and textile materials. Reference is made in this Bulletin to the 1941 Supplements to the Book of Standards on which editorial work is intensively under way, with distribution scheduled for early in November.

There has been forwarded to each member an order blank by which he can procure, at the special members' prices, copies of publications. (In the case of three new publications being issued for the first time—compilations of standards in the field of copper and copper alloys, and mineral aggregates, and the Symposium on Particle Size Measurement, special prospectuses will be mailed to members in December at which time orders can be placed for these books.)

Notes about publications already issued follow:

Natural and Synthetic Rubbers:

The 1941 Edgar Marburg Lecture by Dr. H. L. Fisher, who, in the section devoted to natural rubber covers properties and products, milling, compounding, chemical properties, and related topics; and in the section devoted to synthetic rubbers covers synthesis and structure, definition, nomenclature, composition, compounding, X-ray structure, and devotes considerable space to a number of important properties and the application of synthetic rubbers. The bibliography covers primary references to synthetic rubbers. This lecture, to be included in the 1941 *Proceedings*, was issued in separate pamphlet form, special paper binding. Members who wish to have separate copies can obtain them at 35 cents each; the list price for the 32-page publication is 50 cents.

Symposium on Color—Its Specification and Use in Evaluating the Appearance of Materials:

One of the two symposiums held at the Spring Meeting in Washington. This one, jointly sponsored by the Inter-Society Color Council and A.S.T.M., includes six technical papers by outstanding authorities in this field, with discussion by other technologists. These papers cover many phases of color, but stress those aspects of primary interest to the specifier of appearance attributes of color. A special prospectus on this book was sent to members in August. The price to members is $1.00 in cloth binding; 75 cents, paper; list price, $1.25, cloth; $1.00, paper. 86 pages.

Standards on Cement:

Gives all of the specifications and tests developed by Committee C-1 including the now Standard Specifications for Portland Cement (C 150 – 41) with requirements for five types including high-early-strength, low-heat hydration, and high-sulfate resistance. There are six methods of tests and, in addition to C 150, specifications for natural and masonry cement and for testing sieves. 100 pages, heavy paper cover, to members, 75 cents; list price, $1.00.

Standards on Petroleum Products and Lubricants:

This publication, which has been issued annually since 1926, thus making it the oldest of these committee-sponsored publications, is also the most widely distributed. A 400-page volume with some 82 standards, of which 69 are test methods, 11 specifications, and two, definitions of terms, this latest edition also gives four proposed new methods approved by Committee D-2 for publication as information. The current D-2 report is included which gives in detail the 1941 changes in the standards. Important additions to the standards this year are the specifications for aviation gasoline and tests for knock characteristics of aviation fuels, ignition quality of Diesel fuels, aniline point of petroleum products and for carbonizable substances in paraffin wax. 400 pages, heavy paper cover, to members, $1.50; list price, $2.00.

Standards on Electrical-Heating and Resistance Alloys:

This new compilation, the first to be sponsored by Committee B-4 on Electrical-Heating, Electrical-Resistance, and Electric-Furnace Alloys, covers 110 pages, and the first 500 copies of the book also include through the courtesy of the National Bureau of Standards the extensive technical paper by Messrs. Roeser and Wensel covering "Methods of Testing Thermocouples and Thermocouple Materials," this 36-page paper being reprinted from the National Bureau of Standards *Journal of Research*.

The committee feels it is very fortunate to be able to include this technical contribution because it provides some guidance to the reader in selecting the method which is best adapted to a given set of conditions.

The compilation provides standard methods of test and some specifications prepared by the committee, on electrical-heating materials, electrical-resistance materials, thermostat metals, materials for lamps and radio tubes, and structural and electrical-resistor materials for furnaces.

This committee-sponsored publication is also featured by a technical paper on "Thermostat Metal" prepared especially for Committee B-4 by S. R. Hood, Chief Engineer, W. M. Chace Co. This presents useful information on the subject, covering historical facts, characteristics of thermostat metal, the design of devices depending upon thermostat metal, and methods of testing. (This paper is also being published in the ASTM Bulletin.)

The annual report of the committee, June, 1941, also is included, which gives information regarding the scope of the work under way on these various classes of materials. The committee has recently undertaken the development of methods of testing materials for contacts, and this work is going forward actively. The committee is also carrying forward a program for development of specifications and methods of test for alloys for use at high temperatures (over 1000 F). Heavy paper cover, to members, $1.00; list price, $1.25.

Standards on Textile Materials:

While this annually issued publication sponsored by Committee D-13 on Textile Materials is developed essentially to cover in convenient, compact form *all* of the A.S.T.M. specifications, tolerances, tests, and definitions pertaining to the wide range of textile materials, it represents much more than just a collection of standards. It is a good example of a compilation sponsored by a committee which provides a wealth of other helpful information in a particular field. In addition to 67 specifications and tests covering some 280 pages, there are Appendices providing several proposed methods published as information and comment including a Recommended Practice for Designation of Yarn Construction, Test for Accelerated Aging of Textiles, Methods for Identification of Finishes on Textiles, and other proposals. An excellent series of Photomicrographs of Common Textile Fibers is furnished, also a Yarn Number Conversion Table, Psychrometric Table for Relative Humidity, and Photomicrographs of Defects in Woven Fabrics. Four interesting technical papers presented at a meeting of the committee are included.

The use of this publication has increased from year to year and it is now widely distributed in the textile industry and has come to be recognized as an exceedingly valuable publication. Copies of the 400-page publication are furnished members at $1.25, heavy paper cover, while the list price is $2.00.

Report on Corrosion of Iron and Steel.—Field Tests of Wire and Wire Products:

This *Proceedings* reprint of the annual report of Committee A-5 discusses various committee activities and this year features the first extended report of the Wire Inspection Committee on Field Tests of Wire and Wire Products covering 1939 and 1940 inspections. The results of these atmospheric corrosion tests which have been under way for about four years at eleven test sites are presented in the form of very extensive tables with pertinent information and some discussion of the data by the committee. Those technologists concerned with wire and wire products will find this extensive report of distinct interest. The A-5 pamphlet also gives the record of failures of the sheets at Annapolis and discusses subcommittee activities. To members, 40 cents; list price, 50 cents.

Impact Resistance and Tensile Properties of Metals at Subatmospheric Temperatures:

Prepared by H. W. Gillett, Battelle Memorial Institute, for the Joint Research Committee on Effect of Temperature on the Properties of Metals. From the standpoint of value, particularly to the designers and producers and users of metals at low temperatures, this report deserves a full-page description and comment in this BULLETIN. In preparation for about two years in the Joint Committee through a subcommittee headed by F. B. Foley, the information was submitted by a number of cooperating organizations and then referred to Doctor Gillett who clarified it, added a large amount of material from the literature, principally foreign, supplied critical comment, and appended a comprehensive bibliography. Cooperating with Doctor Gillett were H. W. Russell, S. L. Hoyt, and H. C. Cross.

From about 1906 until 1931, the only compilation of data in this field was Hadfield's report. Then in 1931, H. W. Russell included a valuable summary in the Symposium on Effect of Temperature on the Properties of Metals, and now the Joint Committee has provided in convenient form for all concerned the latest available information. With the applications of metals at low temperatures increasing in number and scope, it is a timely book, and incidentally one of direct concern and value in connection with National Defense problems. A condensed index provides references to important topics covered. The bibliography has been carefully selected. Bound in board covers, with wire binding covering 112 pages, with 142 tables of data, this publication is available to members of the A.S.T.M. and A.S.M.E. at $2.00; list price, $2.50.

Committee on Plastics Advances Work at New York Meeting

A REVIEW OF THE work of Committee D-20 on Plastics as indicated in a statement describing the two-day meeting held at the Hotel Pennsylvania on October 1 and 2, shows that the important activities of the subcommittees are being advanced. In the field of strength properties the committee will study the recently approved Method of Tension Testing of Plastics (D 638 – 41 T) to determine whether certain parts of the procedure can be simplified. Other projects involve the development of needed methods for modulus of elasticity or stiffness factor; the standardizing of high-speed impact and tension impact tests; and the development of methods for measuring shear properties.

The groups dealing with hardness and thermal properties are continuing their studies. The former include mar resistance, a study of bearings, and revived interest in the indentation hardness test. The latter group is completing a round-robin series of tests on coefficient of volume expansion and a test for linear expansion may be drafted. Studies on methods of testing flow of thermoplastics and thermosetting materials are also being continued.

As announced in the opening article in this BULLETIN a Test for Diffusion of Light by Plastics (D 636 – 41 T) and Method of Test for Surface Irregularities of Flat Transparent Plastic Sheet (D 637 – 41T) have been approved by the Society. It was announced at the meeting that a test for haze is practically completed with descriptive nomenclature.

A knowledge of permanence properties is extremely important in considering the applications of the material; accordingly Committee D-20 through its Subcommittee V is pushing the study of effect of heat, water, and such agencies with accelerated weathering tests also under consideration.

The importance of quality requirements has been evident and Subcommittee VI on Specifications realizing the urgency has set up a number of sections which will, as soon as possible, develop specifications for finished parts. At least 20 specifications have been indicated as desirable.

W. E. Emley, National Bureau of Standards, is Chairman of Committee D-20 with W. A. Evans, Bell Telephone Laboratories, Inc., Secretary.

A.P.I. Announces New Viscosity Standards

THE AMERICAN PETROLEUM INSTITUTE'S Committee on Viscosity Standards has prepared a new set of oil standards for viscosimeter calibration. In preparing these new standards two recent developments have been taken into consideration, (1) the general adoption of kinematic viscosimeters in place of Saybolt instruments for routine and control testing, and (2) the adoption of kinematic viscosity limits for Diesel fuels.

To meet these new conditions the committee is now offering the oils in two sizes of containers. These include the quart sample previously supplied and a half-pint sample for those primarily interested in the calibration of kinematic viscosimeters only. Kinematic viscosimeters require only a small volume of oil, thus eliminating the necessity of purchasing a large sample.

The introduction of smaller samples will also reduce the tendency of some testers keeping the samples in stock over long periods of time. Even under the best of conditions oil samples will not remain constant forever, therefore it is desirable to discard old ones and obtain new ones. The committee recommends discarding the sample within eight months after purchase date.

The new series consists of three oils, namely, Alpha 41, Beta 41, and Gamma 41. Their viscosities were determined by Subcommittee V on Viscosity of A.S.T.M. Committee D-2 on Petroleum Products and Lubricants. The official values assigned to them are as follows:

	Alpha 41	Beta 41	Gamma 41
	Kinematic Viscosity		
Centistokes at 100 F.	58.22	383.7	3.032
Centistokes at 122 F.	....	182.7	....
Centistokes at 210 F.	7.68	23.87	....
	Saybolt Universal (by conversion)		
Seconds at 100 F.	269.2	1773	36.1
Seconds at 210 F.	51.3	114.9	....
	Saybolt Furol (by conversion)		
Seconds at 122 F.	....	86.6	....

The kinematic viscosities were determined by a number of laboratories using different types of viscosimeters. In each case, however, distilled water was used as a basis of comparison. The Saybolt Universal values were obtained by conversion using A.S.T.M. Method for Conversion of Kinematic Viscosity to Saybolt Universal Viscosity (D 446 – 39). The Saybolt Furol value was obtained by conversion by the proposed method for conversion of kinematic viscosity to Saybolt Furol viscosity published as information by A.S.T.M. in June, 1941.

Recommended procedures for the calibration of viscosimeters have been published by A.S.T.M. in the Method of Test for Kinematic Viscosity (D 445 – 39 T) and the Method of Test for Viscosity by Means of the Saybolt Viscosimeter (D 88 – 38) for the kinematic and Saybolt viscosimeters, respectively.

The oil standards are available at the following prices:

Quart sample	$5.00 each
One-half pint sample	$2.50 each

Orders for samples should be sent to Dr. T. G. Delbridge, Chairman, 3144 Passyunk Ave., Philadelphia, Pa., with check drawn exactly that way.

1941 Year Book

A COPY OF THE 1941 YEAR BOOK, recently published, has been mailed to each member of the Society who requested one, an opportunity having been given earlier in the year to members to request a copy. Those who did not request one and who have use for it should write A.S.T.M. Headquarters immediately.

This 335-page publication, furnished only to members, is intended for use in connection with the activities of the Society. In addition to a complete membership list (separate lists of Honorary Members and Sustaining Members are included, these individuals and companies being later listed in the complete personnel), the Year Book provides detailed information of the A.S.T.M. committee setup, listing the personnel of various standing committees and subcommittees, technical committees and sections. It is an interesting fact that while some 100 pages are devoted to listing the membership of the Society, it takes over 150 pages to give the complete personnel of the standing committees.

Other material in the Year Book includes a copy of the list of past and present officers, Charter, By-Laws, Regulations governing the standing committees and other information including Recommendations on the Form of Standards which covers standard terms, abbreviations, spelling, and so forth. A number of people find this latter information of considerable interest. General information about the Society is given and there are bound in the book membership application blanks and also a blank covering student membership. A Table of Contents enables material in the Year Book to be located quickly.

Index and List of Standards

WHILE EACH MEMBER of the Society and many other technologists, purchasing agents, and others concerned with engineering materials will be receiving early in November a copy of the latest "Index to A.S.T.M. Standards, Including Tentative Standards," which publication is an essential part of the 1941 Supplements to the Book of Standards, members may wish to procure now a copy of the new "List of Standards" just off press.

This 34-page list gives the latest titles and serial designations of all A.S.T.M. specifications and tests, grouped under specific fields. It is intended primarily to furnish those people who inquire about specifications information on just what A.S.T.M. has available. It is not intended to serve the same purpose as the Index and no attempt is made to list the specifications in particular alphabetical or numeric sequence. Members can obtain copies of this list without charge on request.

New Sectional Committee on Fastness of Colored Textiles

UNDER THE JOINT sponsorship of the American Association of Textile Chemists and Colorists and the A.S.T.M. a new sectional committee has been organized to function under the procedure of the American Standards Association in the field of fastness of colored textiles. One of the chief functions of the A.S.A. is to act as a coordinating body and to bring together in common cause the

activities and projects on similar subjects which may have been under way simultaneously in different organizations. That basically is the background for the new sectional committee, designated L14.

The A.A.T.C.C. has had a number of committees in this field and has developed fastness tests for different textiles including cotton, wool, and silk. Because A.S.T.M. through its Committee D-13 on Textile Materials was also active in this field and other groups were definitely interested, a decision was reached by the A.S.A. Advisory Committee on Ultimate Consumer Goods, a supervisory committee of the A.S.A., to undertake, with the cooperation of the interested bodies, the organization of the sectional committee.

The scope of the project has been stated as follows:

"Correlation of standards covering test methods for the fastness of colored textiles to color-destroying agencies and the evaluation and interpretation of data obtained from such tests—the work to be based upon standards developed by cooperating organizations."

At a meeting held in July a subcommittee was designated to harmonize test methods for color fastness in cottons, this group being headed by Dr. W. D. Appel of the National Bureau of Standards. Other subcommittees will be appointed later.

In addition to harmonizing testing procedures, another important field where the committee can do effective work is in the evaluation and interpretation of data which it is hoped can result in some standardized form for presenting information about the fastness of textiles. A subcommittee in this field is being organized, headed by Dr. Jules Labarthe, Jr., Mellon Institute of Industrial Research.

Official representatives of the Society on this sectional committee are W. M. Scott, Chief, Cotton Chemical Finishing Div., U. S. Bureau of Agricultural Chemistry and Engineering, and A. G. Ashcroft, Product Engineer, Alexander Smith and Sons Carpet Co.; with R. E. Hess, Assistant Secretary, alternate. Mr. Scott is Chairman of Committee D-13's Subcommittee B-4 on Bleaching, Dyeing, and Finishing and Mr. Ashcroft serves as Chairman of D-13's Subcommittee A-3 on Wool and Its Products.

Cement for Panama Canal Covered by A.S.T.M. Standards

IT IS OF INTEREST to note in connection with the use of A.S.T.M. specifications to govern the quality and tests of materials that specifications issued in June by the authorities responsible for the work at the Panama Canal have incorporated the requirement that cement should be Type IV of the A.S.T.M. Tentative Specifications C 150 – 40 T. Type IV is used when a low heat of hydration is required. Information indicates that these specifications are to cover the purchase of 6 million barrels of cement!

It is to be noted that the specifications which apply are based on the tentative standards. By action at the annual meeting the recommendation of Committee C-1 on Cement which is responsible for these specifications was approved, namely, that the tentative standards with certain revisions incorporated be referred to Society letter ballot for adoption as standard.

Cities Specify and Test Commodities Under Centralized Purchasing Plan

MOST AMERICAN cities buying supplies through centralized purchasing departments make strict use of written specifications to protect themselves on purchases, a recent survey by the American Municipal Association showed. Most of the cities maintain a testing laboratory, or use Government or privately owned laboratories, to see that goods received match specifications.

Cities in the larger population groups make a much greater use of written specifications than the smaller communities, according to the survey, which covered 100 of the 125 municipalities reporting the use of centralized purchasing. The total number of large and small cities buying to specification is about 34 per cent of those surveyed.

Most of the cities surveyed reported that their centralized purchasing department was responsible for formulating the standards and specifications used in buying supplies. Sixteen per cent reported the exclusive use of standards and specifications based either on Federal specifications or on those of national trade or technical associations. Four per cent said a special committee prepared the specifications.

Many of the cities indicated that written specifications have been made up to cover nearly every type of commodity they need, from alloys and flower bulbs to uniforms and soap.

If the practice of the 100 cities indicates the trend throughout the country, the survey said, "it would seem that American municipalities are now making extensive use of tests to determine whether samples of commodities submitted with bids, and the purchases actually delivered, comply with representations made by the vendors."

Of 47 cities from which complete information was received, only seven, or 15 per cent, said they never test commodities after delivery to learn if they conform to specifications. In making such tests the cities use college, state or commercial testing laboratories. Nearly all the cities of over 100,000 population, however, maintain some kind of testing laboratory of their own.

Fire Defense

THIS IS THE TITLE of a publication recently issued by the National Fire Protection Association, compiling information prepared by its staff. The book gives a great deal of available material on air-set fires, bombs and sabotage, civilian defense, fire fighting, and the safeguarding of industrial production for defense.

Some of the chapter headings are indicative of the specific subjects covered, including the following: The Incendiary Bomb, Magnesium and Its Alloys, Handling Bombs, Sabotage through Fire, Arson in Times of War, The Ontario Defense Plan, The Maryland Fire Defense Plan, The Massachusetts Fire Department Inventory, Training Auxiliary Firemen, Public Water Supply in the Civil Defense Program, Fire Companies, and Fire Apparatus.

Copies of this 22-page publication can be obtained from the N.F.P.A. office, 60 Batterymarch St., Boston, Mass., at $1.50 each.

Standards Recently Issued

STANDARDS ISSUED by a number of engineering and technical organizations are received by the Society as they are adopted or revised. Since members of the Society may be interested in knowing that such standards are available they will be listed as received in the ASTM BULLETIN.

Recently the following standards have been received:

BRITISH STANDARDS FOR:

Carbon Steel Castings for Ships and for Marine Engine and General Engineering Purposes (No. 592—1940).
Steel Plates for Fireboxes of Locomotive Boilers (No. 24—Part 6, Spec. 16x—1940).
Steel Tubes and Tubulars, Light Weight and Heavy Weight Qualities (No. 789A—1940).
Oxy-Acetylene Welding in Mild Steel (No. 693—1940).
Testing Fusion Welds, Welded Joints, and Weld Metal (Applicable to the Electric Arc Welding of Steel) (No. 709—1940).
High Alumina Cement (No. 915—1940).
Ordinary Portland and Rapid-Hardening Portland Cements (No. 12—1940).
Sampling and Examination of Bituminous Road Mixtures (No. 598—1940).
Brass Bars (High Speed Screwing and Turning) (No. 249—1940).
Brass Bars and Sections (Suitable for Forging) and Drop Forgings (No. 218—1940).
High Tensile Brass Bars and Sections (Grades A and B) (No. 250—1940).
Naval Brass (Admiralty Mixture) Bars and Sections (Suitable for Machining and Forging) and Forgings (No. 251—1940).
Naval Brass (Special Mixture) Bars and Sections (Suitable for Machining and Forging) and Forgings (No. 252—1940).
Phosphor Bronze Bars and Rods for General Purposes (No. 369—1940).
Leaded Gunmetal Castings and Ingots (No. 897—1940) (No. 898—1940).
Leaded Gunmetal Castings and Ingots (No. 900—1940) (No. 901—1940).
Cold Rolled Copper Sheets and Strip (Half-Hard and Annealed) for General Purposes (No. 899—1940).
Naval Brass Die Castings (No. 920—1940).
Aluminum Bars Containing Small Proportions of Copper and Zinc for General Engineering Purposes (No. 918—1940).
Rubber Hose with Woven Fabric Reinforcement (No. 924—1940).
Rubber Mats for Electrical Purposes (No. 921—1940).
Testing Latex, Raw Rubber, and Unvulcanized Compounded Rubber (No. 902—1940).
Testing Vulcanized Rubber (No. 903—1940).
Manila Ropes for General Purposes (No. 431—1940).
Sisal Ropes for General Purposes (No. 908—1940).
Tests for Laboratory Porcelain (No. 914—1940).
Glossary of Aeronautical Terms (No. 185—1940).
Pressure Creosoting of Timber (No. 913—1940).
Steel Conduit and Fittings for Electrical Wiring (No. 31—1940).
Metal Arc Welding in Mild Steel as Applied to General Building Construction (No. 538—1940).
The Determination of the Flow and Drop Points of Fats and Allied Substances (No. 894—1940).
Building Limes (No. 890—1940).
Brass Bars and Sections (Suitable for Forging) and Drop Forgings (No. 218—1940).
Brass Bars (High Speed Screwing and Turning) (No. 249—1940).
High Tensile Brass Bars and Sections (No. 250—1940).
Naval Brass (Admiralty Mixture) Bars and Sections and Forgings (No. 251—1940).
Naval Brass (Special Mixture) Bars and Sections and Forgings (No. 252—1940).
Phosphor Bronze Bars and Rods for General Purposes (No. 369—1940).
Leaded Gunmetal Ingots (85/5/5/5) (No. 897—1940).
Leaded Gunmetal Castings (85/5/5/5) (No. 898—1940).
Cold Rolled Copper Sheets and Strip (No. 899—1940).
Leaded Gunmetal Ingots (87/9/3/1) (No. 900—1940).
Leaded Gunmetal Castings (87/9/3/1) (No. 901—1940).
Colors for Signal Glasses for Railway Purposes (No. 623—1940).

BRITISH STANDARD:

Testing Fusion Welds, Welded Joints and Weld Metal (No. 709—1940).
Method for Direct Reading Hardness Testing (Rockwell Principle) (No. 891—1940).
Glossary of Highway Engineering Terms (No. 892—1940).

AUSTRALIAN STANDARDS FOR:

Electrodes for Metallic Arc Welding (No. A 18—39).
Structural Steel (Excluding Plates) and Australian Standard Rolled Steel Sections for Structural Purposes (No. A 1—40).
Code for Structural Steel in Building (No. CA 1—39).
Welding Code (No. CA 8—39).
Wiring Rules, Part I. Wiring Methods (No. CC 1—40).
Galvanized (Zinc-Coated) Barbed Wire (Nos. N 3 and 4—40; No. K 53, Part II—1935).
Tests for Portland Cement and High Early Strength Portland Cement (No. A 2—39).
Aluminium Stearate (No. K 70—39).
Turpentine and Mineral Turpentine (Nos. K 7 and 8—39).
Porcelain Insulators for Overhead Power Lines and Outdoor Switching Structures (No. C 67—39).
Definitions and General Requirements for Electrical Materials and Equipment (No. C 100—40 Ap.).

CANADIAN STANDARDS FOR:

Cast Iron (No. S 61—1940).
Metallic Arc Welding (Bridges and Buildings) (No. S 59—40).
Steel Structures for Buildings (No. S 16—40).
Insulated Power Cable (No. C 68(A)—1940).
Procedure for Fire Tests on Building Construction and Materials (A 54—1940).

CANADIAN STANDARD SPECIFICATIONS FOR:

Portland Cement (A 5—1940; A 57—1940).
Hard Drawn Aluminum Wire, Aluminum Cable, and Aluminum Cable Steel Reinforced (C 49—1940).

Safety Standards

IN THE SEPTEMBER 1941 issue of *Industrial Standardization*, published by the American Standards Association, 29 West 39th St., New York, N. Y., is a complete list of the safety standards approved by the association. Also given is a list of safety developments and projects being developed under A.S.A. procedure. With the increase in industrial production, particularly in defense industries, safety work is of great importance. Fortunately there is now available, as the list indicates, standards in a number of fields and adherence to these standards should help materially in cutting the accident rate.

A.S.T.M. members and others who are interested in safety work should find it of distinct service to have available a copy of this September issue of *Industrial Standardization*. Single copies can be obtained at 35 cents each.

Other articles in this issue discuss causes of industrial accidents, preventing the collapse of portable grandstands, protecting works in electroplating operations, and the recently approved standard for grinding, buffing, and polishing.

Standard Handbook for Electrical Engineers

THE SEVENTH EDITION of this widely known book prepared by a staff of specialists under the direction of A. E. Knowlton (Associate Editor, for Engineering, of *Electrical World*) is essentially an encyclopedia for those concerned with this field of electrical engineering. Admittedly, no book review can hope to indicate adequately the vast amount of material packed in its more than 2280 pages. A.S.T.M. members will be interested to know that a number of their associates were contributors to this book. The section on Measurements, for instance, was prepared by Past-President F. M. Farmer, and revised by his

associate, Gordon Thompson. The section on Properties of Materials covers some 235 pages and includes as authors E. J. Rutan who describes electrical insulating materials and Professors T. J. Dolan and H. F. Moore of the University of Illinois who cover structural materials. A number of other men active in various phases of A.S.T.M. work prepared sections of the publication.

Among the other topics covered in the 26 sections are Units and Conversion Factors, Prime Movers, Power Plant Economics, Electric Heating and Welding, and Electronics and Electron Tubes.

There is a section on Codes and Standard Practices which includes an extensive list of A.S.T.M. specifications and tests and which lists numerous other references and standards of concern in this field. Also of interest is the section on electrophysics, with its chapter on X-rays.

This valuable publication can be obtained from the McGraw-Hill Book Co., Inc., New York, N. Y., at $8 a copy.

Prize Photographs Used in Chemical News Edition

THE CURRENT (OCTOBER 10) issue of the *News Edition, Industrial and Engineering Chemistry* carries a two-page spread of six photographs which won prize awards at the 1941 A.S.T.M. Photographic Exhibit held in Chicago during the annual meeting. Many A.S.T.M. members, and particularly those concerned with photography, will be interested to note this use of these excellent prints. The photographs, like most of those included in the exhibit, focus attention on interesting aspects of testing and research, or other phases of engineering materials.

Calendar of Society Meetings

(Arranged in Chronological Order)

AMERICAN SOCIETY OF CIVIL ENGINEERS—Fall Meeting, October 15–17, Palmer House, Chicago, Ill.

AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS, Petroleum Division—October 16–18, Dallas, Tex.

AMERICAN SOCIETY FOR METALS—National Metal Congress and Exposition—October 20–24. Benjamin Franklin Hotel and Convention Hall, Philadelphia, Pa.

AMERICAN WELDING SOCIETY—Annual Meeting in conjunction with National Metal Congress, October 20–24, Bellevue-Stratford Hotel, Philadelphia, Pa.

AMERICAN GAS ASSOCIATION—Annual Convention, October 20–24, Atlantic City, N. J.

AMERICAN ASSOCIATION OF TEXTILE CHEMISTS AND COLORISTS—Annual Meeting and Convention, October 31 and November 1, Carolina Hotel, Pinehurst, N. C.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS—Annual Meeting, November 3–5, Cavalier Hotel, Virginia Beach, Va.

AMERICAN PETROLEUM INSTITUTE—Twenty-second Annual Meeting, November 3–7, San Francis and Palace Hotels, San Francisco, Calif.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Annual Meeting, December 1–5, New York, N. Y.

EXPOSITION OF CHEMICAL INDUSTRIES—Eighth Annual Meeting, December 1–6, Grand Central Palace, New York, N. Y.

SOCIETY OF AUTOMOTIVE ENGINEERS—Annual Meeting and Engineering Display, January 12–16, 1942, Book-Cadillac Hotel, Detroit, Mich.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS—Winter Convention, January 26–30, New York, N. Y.

Possible Substitutes for Aluminum Paint

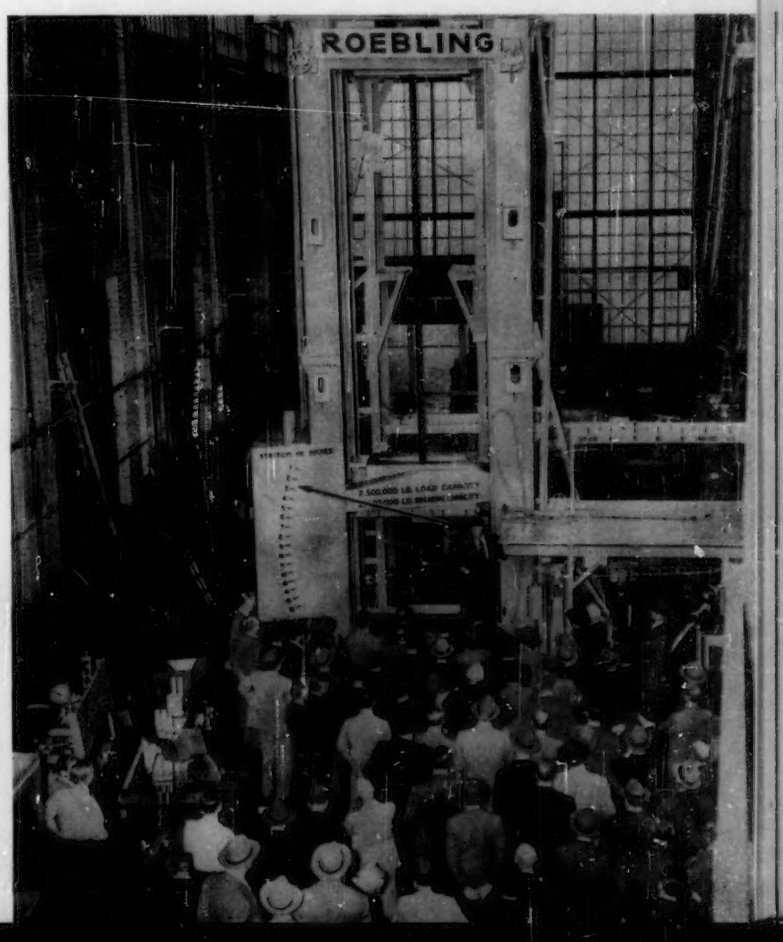
AT THE REQUEST OF the Protective Coating Section of OPM (with other branches of OPM definitely concerned including those concerned with conservation) Messrs. E. F. Hickson of the National Bureau of Standards and H. A. Gardner of the Institute of Paint and Varnish Research have prepared a statement giving recommendations for materials which can be substituted for aluminum paint. It is indicated that with many other materials which are critical now such as tung oil, shellac, etc., there is probably no one paint which has all the desirable properties of aluminum paint for special uses, keeping in mind such properties as durability, visibility, low emissivity, impermeability, opacity, etc. There are, however, a number of types of paints which are available that should prove satisfactory. The various recommendations cover painting of structural steel, metal roofs, smokestacks, interior structural steel, radiators, painting interiors, such as plaster walls and woodwork.

The statement includes references to quite a number of Federal specifications with an indication that similar products may be obtained under trade brands at any paint store and that the paint dealer should readily recognize the material referred to. Copies of this statement can be obtained from the Office of Production Management. A.S.T.M. members, if they wish a copy, can write direct to Mr. Warwick's office, 5326 Social Security Bldg., Washington, D. C.

Roebling Anniversary

Guests of the John A. Roebling's Sons Co. at the celebration of their One-Hundredth Anniversary, September 22, watched an interesting demonstration—testing the strength of 4-in. wire rope which broke at approximately 1,600,000 lb. This company has been a member of A.S.T.M. since 1900, and a number of its technical men have been very active in the Society's work.

Courtesy *Steel*



NEW MEMBERS TO OCTOBER 1, 1941

The following 53 members were elected from July 22 to October 1, 1941:

Chicago District

ALKYDOL LABORATORIES, INC., Adolph Heck, President, 2038 W. Carroll Ave., Chicago, Ill.

GRAHAM, ANDERSON, PROBST & WHITE, M. G. Probst, Partner, 80 E. Jackson Boulevard, Chicago, Ill.

MARTIN-SENOUR CO., THE, R. H. Coe, General Superintendent, 2520 S. Quarry St., Chicago, Ill.

METAL LATH MANUFACTURERS ASSN., Arthur J. Tuscany, Commissioner - Secretary - Treasurer, 208 S. La Salle St., Chicago, Ill.

OAK MANUFACTURING CO., R. E. Wood, Engineer, 1260 Clybourn Ave., Chicago, Ill.

CHERRY, O. A., Research Chemist, Nubean Paint and Varnish Co., Division of The Glidden Co., 1856 N. LeClaire Ave., Chicago, Ill.

KOCOUR, CYRIL, Partner, Kocour Co., 4724 S. Christiana Ave., Chicago, Ill.

LOBLEY, F. A., Chief Engineer, Miles Laboratories, Inc., Myrtle and McNaughton Sts., Elkhart, Ind.

Detroit District

GERITY-ADRIAN MANUFACTURING CORP., W. W. Hunlock, Chief Chemist, Adrian, Mich.

TOLEDO SCALE CO., G. R. Carley, Research Engineer, Toledo, Ohio.

BARLOW, TOM, Foundry Engineer, Vanadium Corporation of America, 2440 Book Building, Detroit, Mich.

GOFF, J. W., Junior Inspector of Ordnance Materials, U. S. War Dept., Kingsbury Ordnance Plant, La Porte, Ind. For mail: Portland, Mich. [J]

LAIRD, J. S., Chemist, Ford Motor Co., Dearborn, Mich. For mail: 22045 Francis Ave., Dearborn, Mich.

PARKE, R. M., Metallurgist, Climax Molybdenum Co. of Michigan, 14410 Woodrow Wilson, Detroit, Mich.

WISEMAN, W. A., Assistant Chief Engineer, The Warner Aircraft Corp., 20263 Hoover Ave., Detroit, Mich.

New York District

ECLIPSE AVIATION, DIVISION OF BENDIX AVIATION CORP., N. E. Woldman, Chief Metallurgical Engineer, Bendix, N. J.

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UNITED CHROMIUM, INC., K. W. Schwartz, Vice-President, 51 E. Forty-second St., New York, N. Y.

JACKSON, B. R., Representative in U.S.A., Anglo-Iranian Oil Co., Ltd., London, E. C. 2, England. For mail: 620 Fifth Ave., New York, N. Y.

NELSON, H. S., Chief Metallurgist, Winchester Repeating Arms Co., Division of Western Cartridge Co., Box 906, New Haven, Conn.

PEASE, F. A., Metallurgical Consultant, 22 North Terrace, Maplewood, N. J.

RICE, KENNETH, Sydney Blumenthal and Co., Inc., Shelton, Conn.

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SNYDER, W. C., JR., President and General Manager, Lewis Foundry and Machine Division, Blaw-Knox Co., Box 1586, Pittsburgh, Pa.

SPRAGUE, W. W., Vice-President, National Mortar and Supply Co., 1520 Grant Building, Pittsburgh, Pa.

TRUEG, A. C., Proprietor and Manager, Pittsburgh Instrument and Machine Co., 1026 Reedsdale St., Pittsburgh, Pa.

Southern California District

BAUMAN, G. A., Manager, Wilmington Branch, The Jaite Co., 830 E. "D" St., Wilmington, Calif.

PATTON, F. E., Metallurgist, The National Supply Co., Box 28, Torrance, Calif.

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Other than A.S.T.M. Districts

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CAMERON IRON WORKS, INC., Herbert Allen, Chief Engineer, Box 1212, Houston, Tex.

CHEVROLET MOTOR AND AXLE, DIVISION OF GENERAL MOTORS CORP., C. E. Zwahl, Chief Metallurgist, P. O. Station "B," Buffalo, N. Y.

IDEAL CEMENT CO., J. F. Kaufman, Chief Engineer, 507 Denver National Building, Denver, Colo.

STEARMAN AIRCRAFT, DIVISION OF BOEING AIRPLANE CO., H. W. Zipp, Chief Engineer, Wichita, Kans.

VULTEE AIRCRAFT, INC., W. G. Weeks, Process Engineer, Nashville Division, Nashville, Tenn.

DUNHAM, H. W., Manager, H. W. Dunham Laboratories, 1015 Fairview Ave., N., Seattle, Wash.

FARREN, P. C., Metallurgist, Greenfield Tap and Die Corp., Research Dept., Greenfield, Mass.

HENDRICK, C. L., Architect, Yonge & Hart, Thiesen Building, Pensacola, Fla.

HOBBS, W. V., Director of Laboratory, Ranco, Inc., Columbus, Ohio. For mail: 4120 Kenny Road, Columbus, Ohio.

INSTITUTE OF PAPER CHEMISTRY, THE, Appleton, Wis.

KANSAS CITY, DEPARTMENT OF PUBLIC WORKS, Reed Mckinley, City Engineer, City Hall, Kansas City, Mo.

MAYFIELD, P. B., Manager, Research and Development, International Creosoting and Construction Co., 2205½ Avenue B, Galveston, Tex.

MILLER, M. L., Consulting Engineer, Tyler Building, Louisville, Ky.

WAGNER, W. C., Associate Professor of Civil Engineering, University of New Mexico, Albuquerque, N. Mex.

Other than U. S. and Its Possessions

FERROCARRILES NACIONALES DE MEXICO, P. M. Hernandez, Sub-Gerente General, 2A Bolivar 19, Mexico, D. F., Mexico.

INDUSTRIAS QUIMICAS DE MEXICO, S. DE R. L., Heinz Klinckwort, Chemist, Apartado 9622, Mexico, D. F., Mexico.

FREEMAN, E. M., Vice-President, Canadian Asbestos Co., 322 Youville Square, Montreal, P. Q., Canada.

GILSON, W. J., General Manager, Eastern Power Devices, Ltd., 1244 Dufferin St., Toronto 4, Ont., Canada.

KNAPP, J. J., Works Manager, John Morrow Screw and Nut Co., Ltd., Ingersol, Ont., Canada.

MALOTAUX, R. N. M. A., Director, N. V. v/h Chemisch Technisch Laboratorium Dr. Lobry de Bruyn, Meeuwenlaan 20, Amsterdam, The Netherlands.

ROBINSON, G. H., Chief Chemist, Burma Cement Co., Ltd., Thayetmyo, Burma.

SOCIEDAD COLOMBIANA DE QUIMICOS, A. M. Barriga Villalba, President, Apartado 18, Bogota, Colombia.

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PERSONALS

» » » News items concerning the activities of our members will be welcomed for inclusion in this column.

H. G. SNEAD, formerly Testing Engineer, Brown-Bellows & Columbia, Corpus Christi, Tex, is now with the Missouri Pacific Lines, Opelousas, La., as Rodman.

R. W. BAKER, who was Assistant to the President, The Flood Co., Cleveland, Ohio, is again connected with the Republic Steel Corp. in Cleveland.

C. W. SCHOFFSTALL is Textile Technologist, U. S. Tariff Commission, Washington, D. C. He was Director of Laboratory, Marshall Field and Co., Chicago, Ill.

J. R. Graf, formerly Sales Engineer, Baldwin-Southwark Division, The Baldwin Locomotive Works, Philadelphia, is now Lieutenant Ordnance, U. S. Army, Philadelphia Ordnance District.

C. E. Paul is now Professor Emeritus of Mechanics, Illinois Institute of Technology, Chicago, Ill.

V. H. Lawrence, who was Assistant to Vice-President, Alan Wood Steel Co., Conshocken, Pa., has been appointed Assistant to the President, The Otis Steel Co., Riverside Works, Cleveland, Ohio.

W. C. Shutts was with the Standard Oil Co. of Venezuela, Caripito, Venezuela. He is now with the Lago Petroleum Corp., Maracaibo, Venezuela.

Fred Burggraf, who, prior to becoming Research Engineer, Highway Research Board, National Research Council, was Materials Engineer with the Calcium Chloride Assn., is now Assistant Director of the Highway Research Board.

S. A. Standing is connected with the Phillips Export Corp., New York, N. Y., as Materials Engineer (Electronics). He was formerly Materials Engineer, Raytheon Production Corp., Newton, Mass.

G. C. Ernst, formerly Assistant Professor of Civil Engineering, University of Maryland, College Park, Md., is now Assistant Professor of Civil Engineering, College of Applied Science, Syracuse University, Syracuse, N. Y.

G. B. Waterhouse has been appointed Technical Consultant, Steel Section, Office of Production Management, Washington, D. C.

D. L. Colwell has a temporary leave of absence from Paragon Die Casting Co. and Elmer E. Mills Corp. to accept an appointment in the Conservation Unit, Conservation Section of the OPM.

R. G. Cone, formerly Resident Engineer, Golden Gate Bridge, Strauss Engineering Corp., San Francisco, Calif., is now Assistant Chief Engineer, Silas Mason Co., Claridge Hotel, Washington, D. C.

L. M. Currie is now Superintendent, Vinylite Division, Bakelite Corp., Bound Brook, N. J. He was Director, Vinylite Division, National Carbon Co., Inc., Cleveland, Ohio. The Plastics Division of National Carbon Co., Inc., in Cleveland is moving to Bound Brook, N. J., to become the Vinylite Division of Bakelite Corp.

C. T. Raber, formerly Chemical Engineer, Glens Falls Portland Cement Co., Glens Falls, N. Y., is now Superintendent of the company.

T. W. Lippert, who has been Metallurgical Editor of *The Iron Age*, New York, N. Y., for several years, was recently appointed Managing Editor.

G. B. Gould, President, Fuel Engineering Co. of New York, has been appointed as advisory consultant of coal prices in the fuel section of OPACS.

H. C. Mougey, Technical Director, Research Laboratories, General Motors Corp., Detroit, Mich., received the Lammey Medal "for meritorious achievement in engineering" from his alma mater, Ohio State University, on June 15. His most notable contribution has been in the development of automobile finishes and in the problem of motor-car lubrication.

W. P. Putnam, President, Treasurer and Technical Director, The Detroit Testing Laboratory, Detroit, Mich., has accepted an appointment as assistant to the coordinator of the Federal Reserves Bank for the Detroit district on problems relating to the defense program.

R. P. Miller, Consulting Engineer, New York, N. Y., for his "Forty-five years of public service in the cause of fire prevention through intelligent engineering" was given recognition at the Twelfth Annual Safety Convention and Exposition of the Greater New York Safety Council, held in April, and was presented with the original Cranach chromolithograph portraying the burning of Barnum's museum, July, 1865.

A. H. White, Professor of Chemical Engineering, and Head, Department of Chemical and Metallurgical Engineering, University of Michigan, Ann Arbor, Mich., was elected President of the Society for the Promotion of Engineering Education at the 1941 meeting held at the University of Michigan.

H. J. Gough, formerly Director of Scientific Research, War Office, Whitehall, London, S.W.1, England, is now Deputy Controller-General of Research and Development, Ministry of Supply, Shell Mex House, Strand, London, W.C.2, England.

NECROLOGY

We announce with regret the death of the following members and representatives:

H. P. Hayden, Asphalt Technologist, Plainfield, N. J. Member since 1923.

Horace A. Staples, Vice-President, Phelps Dodge Copper Products Corp., American Copper Products Division, New York, N. Y. Member since 1921. At the time of his death, Mr. Staples was a member of Committees B-1 on Copper and Copper-Alloy Wires for Electrical Conductors, B-2 on Non-Ferrous Metals and Alloys, B-5 on Copper and Copper Alloys, Cast and Wrought, and D-13 on Textile Materials. He also represented Committee B-1 on the Coordinating Committee on Non-Ferrous Metals and Alloys, and was formerly a representative of A.S.T.M. on the former Joint Committee on Trolley Wire Specifications.

Harold J. Stein, Director of Research, Chemistry, and Metallurgy, Allis-Chalmers Manufacturing Co., West Allis, Wis. Because of the widespread interest of his company, Mr. Stein, who served as the company representative on technical committees, was a member of a large number including numerous subcommittees of A-1 on Steel, A-3 on Cast Iron, and B-2 on Non-Ferrous Metals and Alloys. The company was also represented on Committees B-5 on Copper and Copper Alloys, Cast and Wrought and D-5 on Coal and Coke.

John F. Davis, Testing Engineer, Robert W. Hunt Co., New York, N. Y. Member since 1927. Mr. Davis had been a member of Committee D-8 on Bituminous Waterproofing and Roofing Materials and Subcommittee III on Investigation of Bituminous Grouts and Mastics Used for Waterproofing Purposes for several years. He had also represented the Society through the Robert W. Hunt Co. on the former Joint Committee on Investigation of the Effect of Phosphorus and Sulfur in Steel.

J. B. Mosley, Chief Chemist, The Ajax Metal Co., Philadelphia, Pa. Affiliated with his company since 1909, Chief Chemist since 1925, Mr. Mosley was particularly active in the work of Committee E-3 on Chemical Analysis of Metals, serving on several of its divisions and subcommittees, and was chairman of the group on Lead, Tin, Antimony, Bismuth and Their Alloys.

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